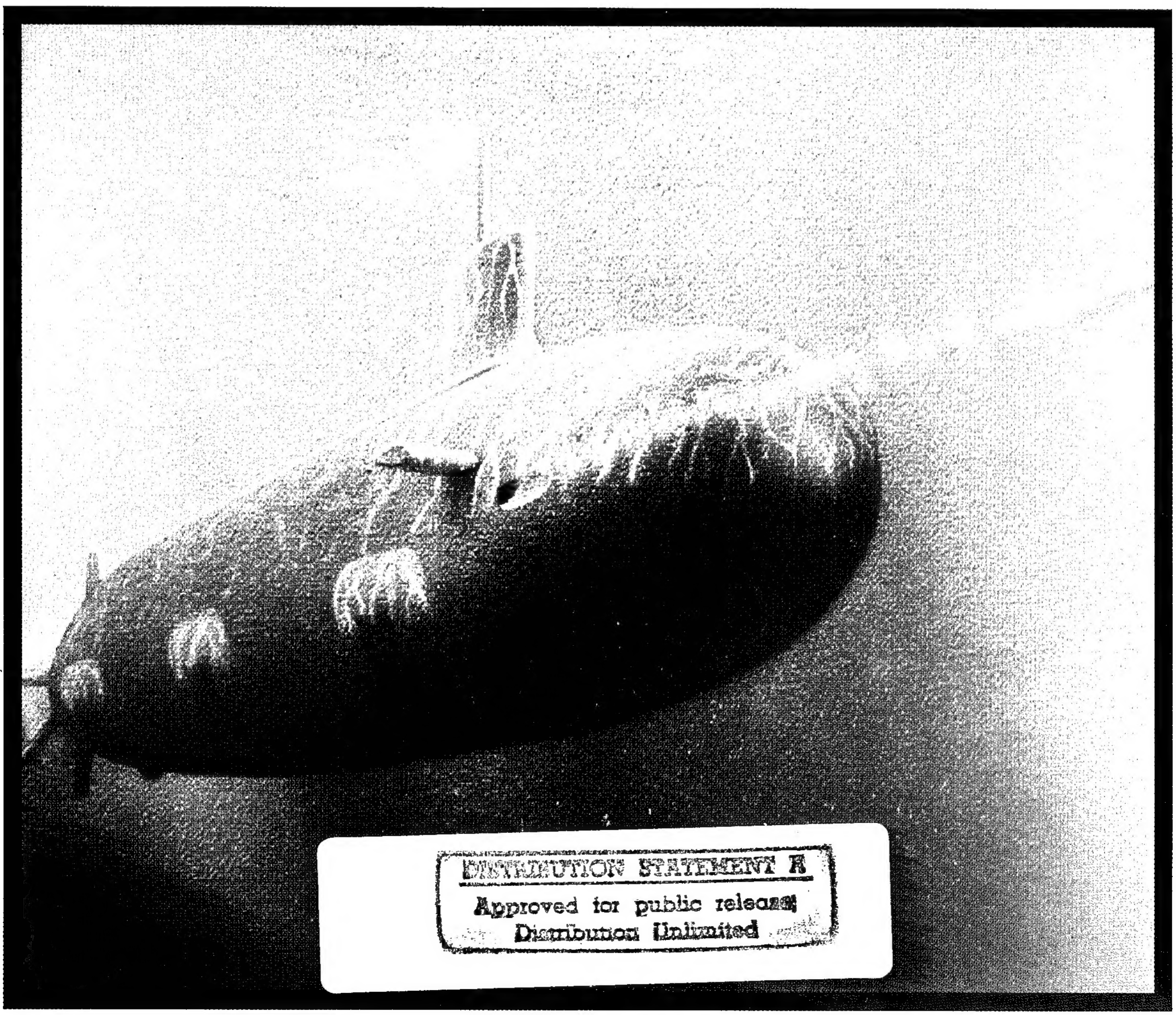
DRAFT ENVIRONMENTAL IMPACT STATEMENT

SHOCK TESTING THE SEAWOLF SUBMARINE

JUNE 1996

DEPARTMENT OF THE NAVY



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SHOCK TESTING THE SEAWOLF SUBMARINE

Department of the Navy

June 1996

RESPONSIBLE AGENCIES:

Department of the Navy (lead agency)
National Marine Fisheries Service (cooperating agency)

PROPOSED ACTION AND GEOGRAPHIC LOCATION:

Shock Testing the SEAWOLF Submarine
Offshore Mayport, Florida or Norfolk, Virginia

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TYPE OF REPORT:

Draft Environmental Impact Statement (DEIS)

ABSTRACT:

This DEIS evaluates the environmental consequences of shock testing the SEAWOLF submarine at an offshore location. The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity sometime between 1 April and 30 September 1997. The DEIS evaluates a "no action" alternative and analyzes in detail two alternative areas offshore of Mayport, Florida and Norfolk, Virginia. Alternatives are compared with respect to project purpose and need, operational criteria, and environmental impacts. Most environmental impacts of shock testing would be similar at Mayport or Norfolk. These include minor and/or temporary impacts to the physical and biological environments and existing human uses of the area. However, the number of marine mammals potentially affected by the detonations would be about eight times lower at Mayport than at Norfolk. Thus, the preferred alternative is to shock test the SEAWOLF offshore of Mayport, Florida, with mitigation to minimize risk to marine mammals and turtles. If the Mayport area is selected, the shock tests would be conducted between 1 May and 30 September 1997 to minimize risk to sea turtles, which are more abundant at the Mayport area during April.

EXECUTIVE SUMMARY

This document is a Draft Environmental Impact Statement (DEIS) for shock testing the SEAWOLF submarine. The DEIS was prepared in accordance with Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions;" the National Environmental Policy Act (NEPA) of 1969; the regulations implementing NEPA issued by the Council on Environmental Quality (CEQ), 40 Code of Federal Regulations (CFR) Parts 1500-1508; and Navy regulations implementing NEPA procedures (32 CFR 775). The Department of the Navy is the lead agency and the National Marine Fisheries Service (NMFS) is a cooperating agency for the DEIS.

PROPOSED ACTION

The proposed action is to shock test the SEAWOLF submarine at an offshore location. The DEIS analyzes in detail alternative areas offshore of Mayport, Florida and Norfolk, Virginia. The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity sometime between 1 April and 30 September 1997. If the Mayport area, the preferred alternative, is selected, the shock tests would be conducted between 1 May and 30 September 1997 to minimize risk to sea turtles, which are more abundant at the Mayport area during April. The series of five detonations would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems prior to the submarine experiencing the next level of shock intensity.

PURPOSE AND NEED

The USS SEAWOLF is the first of a new class of submarines being acquired by the Navy. The class is expected to consist of three submarines, with the second currently under construction. SEAWOLF class submarines will be the largest and most capable fast attack submarines in the fleet. Features include reduced acoustic and electromagnetic signatures, improved speed, greater maximum operating depth, greater ordnance capacity, and other technological improvements reflecting the state-of-the-art in submarine design.

In accordance with Section 2366, Title 10, United States Code (10 USC 2366), a covered system, such as a submarine, cannot proceed beyond initial production until realistic survivability testing of the system is completed. Realistic survivability testing means testing for the vulnerability of the system in combat by firing munitions likely to be encountered in combat with the system configured for combat. This testing is commonly referred to as "Live Fire Test & Evaluation" (LFT&E). The Navy has established a LFT&E program to complete the survivability testing of SEAWOLF Class submarines as required by 10 USC 2366. The SEAWOLF LFT&E program includes a ship shock test. A ship shock test is a series of underwater detonations that propagate a shock wave through a ship's hull under deliberate and controlled conditions. Shock tests simulate near misses from underwater explosions similar to those encountered in combat.

The purpose of the project is to shock test the USS SEAWOLF so that the resultant data can be used to assess the survivability of the submarine. This project is needed

because computer modeling and component testing on machines or in surrogates does not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366. Only by testing the manned submarine with the appropriate systems operating can an adequate assessment of the survivability of the ship be determined in accordance with 10 USC 2366. Shock tests have proven their value as recently as the Persian Gulf War when ships were able to survive battle damage and continue their mission because of ship design, crew training, and survivability lessons learned during previous shock tests.

The SEAWOLF was christened in June 1995 and is expected to be delivered to the Navy in the summer of 1996. Sea trials will begin about three months before delivery to the Navy, and shakedown (operational) tests and trial operations will be conducted on the ship for about a year. Because of the long series of initial tests, shock testing cannot occur before April 1997. Shock testing must be completed before October when unfavorable weather conditions are more likely occur and prior to the ship's scheduled Post Shake Down Availability beginning following the shock test in 1997. During this availability, the ship will be thoroughly inspected prior to unrestricted fleet operations in 1998.

ALTERNATIVES

The DEIS evaluates a "no action" alternative and alternative areas for the proposed shock testing. Alternative offshore areas for shock testing are compared from operational and environmental perspectives. A preferred alternative has been identified based on these comparisons.

No Action

Under the "no action" alternative, no new activities affecting the physical environment would be conducted to predict the response of SEAWOLF class submarines to underwater detonations. This alternative would avoid all environmental impacts of shock testing.

As described in Section 1.1 of the DEIS, the Navy has established a Live Fire Test and Evaluation (LFT&E) program to complete the survivability testing of the SEAWOLF class submarines. The program consists of three major areas which together provide the data necessary to assess the SEAWOLF's survivability: computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. The SEAWOLF LFT&E program already includes the maximum reasonable amount of computer modeling and component testing. Only by testing the entire ship manned with the appropriate systems operating can the shock response of the entire ship, including the interaction of ship systems and components, be obtained and an adequate assessment of the survivability of the submarine be determined in accordance with 10 USC 2366. The intent of 10 USC 2366 is to ensure that the combat survivability of the weapon system (submarine) is assessed before the system is exposed to hostile fire. The information obtained during the shock test is used to improve the shock resistance of the ship and therefore reduce the risk of injury to the crew. The "no action" alternative would prevent the Navy from being able to make the survivability assessment required by 10 USC 2366.

As the "no action" alternative involves no activity affecting the physical environment, it is not individually analyzed further in the DEIS. The "no action" alternative is implicit in the environmental analysis throughout the document. The Existing Environment section provides a "no action" benchmark against which the proposed action can be evaluated. The Environmental Consequences section compares impacts of an action (shock testing) with the alternative of "no action."

Alternative Areas for the Proposed Action

The remaining alternative discussed is the proposed action, which is to shock test the SEAWOLF at an offshore location. Several possible general areas for shock testing were evaluated by the Navy, as described below. The Navy has identified the general offshore areas which meet certain operational criteria, and has identified a preferred area. The final specific shock test site, within a particular area, would not be selected until 2 to 3 days before the test based on marine mammal and turtle surveys (see Mitigation).

Operational Requirements

Alternative areas for shock testing the SEAWOLF were evaluated by the Navy according to operational criteria. A location on the east coast would best meet the Navy's operational needs because that is where the SEAWOLF will be homeported and where all sea trials will occur. A suitable area must have a water depth of 152 m (500 ft) and be within a reasonable distance of required Navy facilities (Naval Station support facility, submarine repair facility, ordnance storage/loading facility, and supporting ships and aircraft). Calm seas and good visibility are needed, and there must be little or no ship traffic in the area.

Five east coast areas were identified that could potentially meet the Navy's operational requirements: Mayport, Florida; Norfolk, Virginia; Groton, Connecticut; Charleston, South Carolina; and Key West, Florida. Charleston was eliminated because of the closure of the Charleston Navy Yard and Charleston Naval Station under the Base Closure and Realignment (BRAC) process (i.e., facilities and vessels to support the test would not be available). The water depth at the Key West area is too great for the planned shock testing. In addition, the Key West area lacks the industrial base to support submarine repairs or drydocking, and there is no surface vessel homeport nearby which could provide Navy assets (ships and planes) to support the test. The three remaining areas (Mayport, Norfolk, and Groton) were compared with respect to operational criteria. The analysis showed that only the Mayport and Norfolk areas meet all of the Navy's operational requirements and that these two areas are rated as nearly equal. Thus only the Mayport and Norfolk areas are included in the detailed environmental analysis in the DEIS.

Environmental Considerations

At both the Mayport and Norfolk areas, possible test sites were first defined as any point along the 152 m (500 ft) depth contour within 185 km (100 nmi) of a naval station and a submarine repair facility. Environmental features near each area were mapped, including marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, and critical habitat for endangered or threatened species. Buffer zones

were developed to avoid impacts to these areas and associated biota. Portions of the 152 m (500 ft) depth contour were excluded as summarized below.

At the Mayport area, there are no marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, or critical habitat areas. Therefore, all points along the 152 m (500 ft) depth contour are considered potential shock testing locations.

At the Norfolk area, the portion of the 152 m (500 ft) depth contour passing through the proposed Norfolk Canyon Marine Sanctuary, along with a 4.6 km (2.5 nmi) buffer on either side, was excluded. The entire area north of the proposed sanctuary was eliminated due to the presence of several shipwrecks near the area. All remaining points along the 152 m (500 ft) depth contour are considered potential shock testing sites.

Comparison of Alternatives

Table ES-1 summarizes the analysis of alternatives with respect to project purpose and need, operational criteria, and environmental impacts. As discussed above, the "no action" alternative (including computer modeling and component testing) is not a reasonable alternative because it would not provide the information and data necessary to support an assessment of the survivability of the ship in accordance with 10 USC 2366. Operational comparison of alternative areas for shock testing showed that the Mayport and Norfolk areas meet all of the Navy's operational requirements and are rated as nearly equal.

Potential environmental impacts of shock testing at the Mayport and Norfolk alternative areas are compared in **Table ES-2** and discussed below under Environmental Consequences. Most environmental impacts of shock testing would be similar at Mayport or Norfolk. These include minor and/or temporary impacts to the physical and biological environments and existing human uses of the area. However, the two areas differ significantly with respect to potential impacts on marine mammals. Because of the difference in marine mammal densities between the two areas, the number of marine mammals potentially affected by the detonations would be about eight times lower at Mayport than at Norfolk. The number of turtles potentially affected would be about the same at either area. Considering all components of the physical, biological, and socioeconomic environment, potential impacts would be less at the Mayport area.

Preferred Alternative

The preferred alternative is to shock test the SEAWOLF submarine offshore of Mayport, Florida, between 1 May and 30 September with mitigation to minimize risk to marine mammals and turtles. This alternative meets the project purpose and need, satisfies operational criteria, and minimizes environmental impacts. The Norfolk area also meets the project purpose and need and satisfies operational criteria; however, the higher density of marine mammals in the area could increase the risk of impacts.

Table ES-1. Summary of alternatives analysis.

Basis for Comparison	Alternative			
	No Action (Includes Maximum Reasonable Amount of Computer Modeling and Component Testing)	**Shock Testing at an Offshore Location**		
		Groton	Mayport	Norfolk
Meets project purpose and need	No	Yes	Yes	Yes
Meets operational criteria	No further analysis (alternative does not meet project purpose and need)	No	Yes	Yes
Potential environmental impacts	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	Less risk of impacts to marine mammals at Mayport. Other impacts similar at the two sites. **See Table ES-2 for details.**	

Table ES-2. Comparison of potential environmental impacts of shock testing at the Mayport and Norfolk areas.

Environmental Component	Section of DEIS Analyzing Potential Impacts	Description of Potential Impact	Comparison of Alternative Areas
IMPACTS EVALUATED UNDER NEPA [a] (impacts onshore and within U.S. territorial seas)			
Physical Environment	4.1.1	No significant direct or indirect impacts on geology and sediments, air quality and noise, or water quality.	Mayport and Norfolk similar.
Biological Environment	4.1.2	No significant direct or indirect impacts on marine biota, including plankton, pelagic fish, marine mammals, sea turtles, benthic organisms, and seabirds.	Mayport and Norfolk similar.
Socioeconomic Environment	4.1.3	No significant direct or indirect impacts on the local economy, including ship traffic and the fishing and tourism industries.	Mayport and Norfolk similar.
IMPACTS EVALUATED UNDER EXECUTIVE ORDER 12114 (impacts outside U.S. territorial seas)			
Physical Environment			
Geology and sediments	4.2.1.1	Metal fragments will be deposited on the seafloor. No cratering or sediment disturbance expected.	Mayport and Norfolk similar.
Air quality	4.2.1.2	Temporary, localized increase in concentrations of explosion products in the atmosphere. No hazard to marine or human life.	Mayport and Norfolk similar.
Water quality	4.2.1.3	Temporary, localized increase in concentrations of explosion products in the ocean. No hazard to marine life.	Mayport and Norfolk similar.

Table ES-2. (Continued).

Environmental Component	Section of DEIS Analyzing Potential Impacts	Description of Potential Impact	Comparison of Alternative Areas
Biological Environment			
Plankton	4.2.2.1	Plankton near the detonation point would be killed, but populations would be rapidly replenished through reproduction and mixing with adjacent waters.	Mayport and Norfolk similar.
Fish	4.2.2.2	Pelagic (water column) fish near the detonation point may be killed or injured. Many of the same species occur at both areas. Demersal (bottom) fish will not be affected.	Mayport and Norfolk similar.
Marine mammals	4.2.2.3	Mitigation will minimize risk, but marine mammals could be killed or injured if not detected within the safety range. At greater distances, animals may experience brief acoustic discomfort, with no lasting effects expected.	Much less risk of impacts at Mayport because marine mammal densities are much lower there.
Sea turtles	4.2.2.4	Mitigation will minimize risk, but turtles could be killed or injured if not detected within the safety range. At greater distances, turtles may experience brief acoustic discomfort, with no lasting effects expected.	Mayport and Norfolk similar. Testing would not occur at Mayport during April when turtle densities are higher.
Benthos	4.2.2.5	No direct effect on benthic organisms is expected. No habitat disturbance is expected. Metal fragments deposited on the seafloor will be colonized by invertebrates and attract fish.	Mayport and Norfolk similar.

Table ES-2. (Continued).

Environmental Component	Section of DEIS Analyzing Potential Impacts	Description of Potential Impact	Comparison of Alternative Areas
Seabirds	4.2.2.6	Seabirds above the detonation point could be killed or stunned by the plume of water ejected into the air. Other seabirds resting or feeding at the surface could be killed or injured by the shock wave. It is unlikely that more than a few birds would be affected.	Mayport and Norfolk similar.
Socioeconomic Environment			
Commercial and recreational fisheries	4.2.3.1	Individuals of commercial or recreational fishery species may be killed or injured, but no significant impact on fishery stocks is expected. Commercial and recreational fishing activities within 18.5 km (10 nmi) of the detonation point will be temporarily interrupted.	Mayport and Norfolk similar.
Ship traffic	4.2.3.2	Ship traffic passing within 18.5 km (10 nmi) of the detonation point would need to alter course or be escorted from the area.	Mayport and Norfolk similar.

a Shore support operations and movement of vessels and aircraft within territorial seas are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases.

ENVIRONMENTAL CONSEQUENCES

Impact discussions in the Environmental Consequences section are divided into separate subsections to distinguish between those aspects of the proposed action evaluated under NEPA and those evaluated under Executive Order 12114. NEPA applies to activities and impacts within U.S. territory, whereas Executive Order 12114 applies to activities and impacts outside territorial seas. The proposed action includes operations that would occur both within and outside U.S. territory. Shock testing and associated mitigation operations would occur at least 78 km (42 nmi) offshore at the Mayport area or 54 km (29 nmi) at the Norfolk area, well outside U.S. territorial seas. No impacts from the actual test (detonation of explosives) would occur in U.S. territory. The only operations that would occur within territorial limits are shore support activities and vessel and aircraft movements in territorial waters (i.e., transits between the shore base and the offshore shock testing site). These shore support activities and vessel and aircraft movements are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Under the NEPA evaluation, no significant direct or indirect impacts are expected at either Mayport or Norfolk; therefore, the rest of this discussion focuses on impacts evaluated under Executive Order 12114.

The proposed action involves underwater detonations which would produce a shock wave and noise, release chemical products into the ocean and atmosphere, and deposit metal fragments on the seafloor. During each test, there would be increased vessel traffic, including ships and aircraft monitoring for marine mammals and turtles. Routine ship traffic (including commercial and recreational fishing vessels) would be temporarily excluded from the test area.

Underwater explosions would release chemical products into the ocean and atmosphere and deposit metal fragments on the seafloor. Due to the low initial concentrations and rapid dispersion of the chemical products, they would pose no hazard to marine or human life. Predicted atmospheric concentrations are well below human safety standards within 305 m (1,000 ft) downwind. Predicted concentrations in the surface pool above the detonation point are below water quality criteria. The small metal fragments are not expected to produce adverse impacts on the seafloor; they would provide a substrate for growth of epibiota and attract fish.

Fish and other small marine life near the detonation point would be killed or injured by the shock wave. A large fish kill would not be expected because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Mitigation). Small pelagic fish with swimbladders (e.g., dwarf herring, round scad, Atlantic menhaden, and chub mackerel) are the ones most likely to be affected if present within about 1,400 m (4,600 ft) of the detonation point. Larger pelagic fish such as billfish, dolphinfish, tunas, and wahoo may be affected within a radius of about 762 m (2,500 ft). Fish without a swimbladder (e.g., sharks) are unlikely to be affected unless they are within about 22 m (73 ft) of the detonation point. Although individual fish would be killed and injured, no impact on fish populations is expected because the species found at the Mayport and Norfolk areas are abundant and widely distributed. Other small marine life such as plankton would also be affected but would be rapidly replenished through population growth and mixing with adjacent waters. Because benthic and demersal organisms would experience only the direct, positive pressure wave and

reflections from the bottom, bottom dwelling fish and invertebrates are unlikely to be affected at either area.

Several species of marine mammals could occur at either the Mayport or Norfolk area. Two main types of potential direct impacts on marine mammals are discussed in the DEIS. First, animals may be killed or injured if they are present near the detonation point and not detected during pre-test monitoring. Second, animals at greater distances may experience temporary acoustic discomfort. Behavioral responses and possible indirect impacts to marine mammals are also discussed but are not considered significant. At either Mayport or Norfolk, mitigation methods would result in selection of a small test site with very low densities of marine mammals (see Mitigation). In addition, pre-detonation aerial surveys, surface observations, and passive acoustic monitoring would be used to minimize the risk of death or injury. However, because of the difference in marine mammal densities between areas, the number of marine mammals potentially killed, injured, or experiencing acoustic discomfort would be about eight times lower at Mayport than at Norfolk.

Potential impacts to sea turtles also differ between areas, but not as much as for marine mammals. With the month of April excluded from testing at Mayport, the number of turtles potentially killed, injured, or experiencing acoustic discomfort would be about the same at either area. Mitigation would be equally effective at both areas because one species (the loggerhead sea turtle) accounts for most of the population at both locations. Mitigation would be much less effective for sea turtles than for marine mammals because sea turtles are relatively small, do not swim in groups, are rarely on the surface, and do not make sounds.

A few seabirds on the water surface or in the air immediately above the detonation point could be killed or stunned by the plume of water ejected into the air. As part of the mitigation plan, the Navy would postpone detonation if flocks of seabirds were sighted within the safety range. This would avoid any large mortality of seabirds. The U.S. Fish and Wildlife Service has concluded that there are no endangered or threatened bird species or critical habitat that would be adversely affected by the proposed action (see Appendix C).

Fishing vessels and other ships and aircraft would be excluded from an area of 9 km (5 nmi) radius during each shock test. Ships within a 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the area. The most common fishing activities at both areas are surface and bottom longlining and trolling. Due to the short duration of the tests and advance warning through *Notices to Airmen and Mariners*, the interruption is not expected to significantly affect commercial or recreational fisheries or other ship traffic at either Mayport or Norfolk.

MITIGATION

The proposed action includes mitigation designed to minimize risk to marine mammals and turtles. The main mitigation measures include (1) a schedule shift at Mayport (no testing in April to avoid higher densities of sea turtles); and (2) a detailed marine mammal and sea turtle mitigation plan that includes test area selection and pre- and post-detonation monitoring. The marine mammal and sea turtle mitigation plan is summarized below and described in detail in Section 5.0 of the DEIS. Other mitigation

measures described in the DEIS include environmental buffer zones to avoid impacts to certain environmental features; an exclusion zone to avoid impacts to routine vessel and air traffic; and measures to deal with unexploded ordnance in the unlikely event of a misfire.

Schedule Shift to Avoid High Turtle Densities at Mayport

Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September 1997. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

Marine Mammal and Sea Turtle Mitigation Plan

A detailed Marine Mammal and Sea Turtle Protection/Mitigation Plan is presented in Section 5.0. The plan includes the same type of mitigation and monitoring efforts that were used successfully during the shock trial of the USS JOHN PAUL JONES in 1994. Those shock trial operations included two 4,536 kg (10,000 lb) detonations and resulted in no deaths or injuries of marine mammals.

The mitigation plan represents the final step in a sequence of actions to avoid or reduce environmental impacts. The Mayport and Norfolk areas were initially selected based on the Navy's operational requirements. Then, portions of the Norfolk area were excluded based on environmental considerations, as noted above. The schedule for testing at Mayport was shifted to avoid high turtle densities which may occur during April. Finally, the results of impact analysis in the Environmental Consequences section were used to identify a preferred alternative area (Mayport) based on the lower density of marine mammals.

The mitigation plan would build upon these previous efforts to avoid or reduce environmental impacts. The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If post-detonation monitoring showed that marine mammals or turtles were killed or injured as a result of a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

The concept of a ***safety range*** is integral to the mitigation plan. Detonation would be postponed if marine mammals or turtles were detected within the safety range radius of 3.8 km (2.05 nmi) around the detonation point. The radius of the safety range is based on the maximum distance for non-lethal injury to a marine mammal and is more than

twice the maximum distance for lethality to marine mammals and turtles. A 1.8 km (0.95 nmi) ***buffer zone*** has also been added to the safety range to accommodate the possible movement of animals into the safety range. That is, the area encompassed within a 5.6 km (3 nmi) radius from the detonation point would be monitored in an effort to detect any marine mammals or turtles approaching the safety range.

The mitigation plan includes three components: (1) aerial surveys/monitoring; (2) shipboard monitoring from the operations vessel and the Marine Animal Recovery Team (MART) vessel; and (3) passive acoustic monitoring using the Marine Mammal Acoustic Tracking System (MMATS). Aerial and shipboard monitoring teams would identify and locate animals on the surface, whereas the acoustic monitoring team would detect and locate calls from submerged animals. This combination of monitoring components would be used to detect marine mammals or turtles within the safety range and to minimize the risk of impacts to these animals.

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LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
BRAC	Base Closure and Realignment
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CL	Ceiling concentration
DEIS	Draft Environmental Impact Statement
DOI	Department of the Interior
EPA	Environmental Protection Agency
FEIS	Final Environmental Impact Statement
GPS	Global Positioning System
HBX	High Blast eXplosive
LFT&E	Live Fire Test & Evaluation
MART	Marine Animal Recovery Team
MBTA	Migratory Bird Treaty Act
MMATS	Marine Mammal Acoustic Tracking System
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSSN	New Attack Submarine
OPNAVINST	Chief of Naval Operations Instruction
OSHA	Occupational Safety and Health Administration
OTC	Officer in Tactical Command
PERSTEMPO	Personnel Tempo (Navy regulations)
PTS	Permanent threshold shift
ROD	Record of Decision
STEL	Short-term exposure limit
TTS	Temporary threshold shift
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service

1.0 INTRODUCTION

This document is a Draft Environmental Impact Statement (DEIS) for shock testing the SEAWOLF submarine. The Department of the Navy is the lead agency and the National Marine Fisheries Service (NMFS) is a cooperating agency for the DEIS.

1.1 BACKGROUND

The USS SEAWOLF is the first of a new class of submarines being acquired by the Navy. The class is expected to consist of three submarines, with the second currently under construction. SEAWOLF class submarines will be the largest and most capable fast attack submarines in the fleet. Features include reduced acoustic and electromagnetic signatures, improved speed, greater maximum operating depth, greater ordnance capacity, and other technological improvements reflecting the state-of-the-art in submarine design.

In accordance with Section 2366, Title 10, United States Code (10 USC 2366), a covered system, such as a submarine, cannot proceed beyond initial production until realistic survivability testing of the system is completed. Realistic survivability testing means testing for the vulnerability of the system in combat by firing munitions likely to be encountered in combat with the system configured for combat. This testing and assessment is commonly referred to as "Live Fire Test & Evaluation" (LFT&E). The purpose of the legislation and this testing is to ensure that the vulnerability of the system under combat conditions, in this case a submarine, is known. However, realistic testing by firing real torpedoes at the ship or detonating a real mine against the ship's hull could result in the loss of a multi-billion dollar Navy asset. Therefore, the Navy has established a LFT&E program to complete the survivability testing of the SEAWOLF Class submarines as required by 10 USC 2366. The LFT&E program consists of three major areas, which together, provide the data necessary to assess the SEAWOLF's survivability: computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship.

Computer modeling is conducted to predict the general shock response motions of the SEAWOLF Class submarine to underwater explosions. The computer analysis predicts accelerations, velocities, and displacement values which correspond to shock inputs to submarine equipment and systems. These predictions can be compared with component shock test qualification results or previously recorded shock test data to establish an engineering baseline for possible equipment/component damage. These comparisons are used to assess the survivability of the ship.

However, computer modeling alone cannot accurately predict the survivability of the submarine. A major problem with existing computer models is that they predict response motions but not failure modes. Computer modeling predictions are best used to evaluate the structural integrity of foundations, cabinets, or housings that support and enclose equipment. For example, computer modeling can predict whether or not a steel foundation would bend or deform, or whether attachment welds or hold down bolts would fail, but they cannot predict the broad range of complex failure mechanisms which could occur inside sophisticated electronic components or complex mechanical systems. Also,

the predictions address the structural integrity of the item, not the operability of equipment or systems which is demonstrated during equipment shock qualification tests and a ship shock test.

Although computer models are helpful in designing new ships, combat experience has demonstrated that unknown or unexpected failure modes cannot be adequately predicted with models. Furthermore, the unique and complex design features challenge computer models due to the complexity of the component or system and because there is little empirical evidence (data) to validate the predictions of the models.

Component and surrogate testing also provides essential information regarding the survivability of the submarine. Nearly 6,000 SEAWOLF components will be shock tested/qualified as part of the SEAWOLF LFT&E program. The Navy tests components on specially designed test machines and fixtures in the laboratory. These machines provide a rapid acceleration to the equipment installed on the fixture. The damage, or lack of damage, resulting from the test assists in the assessment of the components performance under a shock load. These laboratory test machines are limited by the weight of the item to be tested; therefore, the Navy has developed and constructed submarine sections, called surrogates, to house the very large components. The Navy tests these large surrogate sections in specially constructed underwater explosion test facilities also known as "ponds." The usefulness of this testing is limited because the equipment is often not energized or operational, and the entire system is typically so large that it cannot fit completely into even the largest surrogate section. Therefore the shock effects of the overall system and the system's interaction with other ship systems and structure cannot be fully evaluated.

Shock testing of the entire ship provides much of the information missing from computer modeling and analysis and component shock testing. A ship shock test is a series of underwater detonations that propagate a shock wave through a ship's hull under deliberate and controlled conditions. Shock tests simulate near misses from underwater explosions similar to those encountered in combat. The ship is manned with the appropriate systems operating. The shock response of the ship systems and the interaction of the entire ship and with the other systems and components is obtained. Only by testing the entire ship in such a configuration can an adequate assessment of the survivability of the ship be determined in accordance with 10 USC 2366.

1.2 PROJECT PURPOSE AND NEED

The purpose of this project is to shock test the USS SEAWOLF so that the resultant data can be used to assess the survivability of the submarine. Ship shock tests have been performed in the past. Typically the lead ship of a new class of ships constructed for the Navy is shock tested to assess the ship's survivability and vulnerability. Occasionally the shock testing of the lead ship of a class is postponed, due to scheduling conflicts, to a later ship in the class. However, the Navy's goal is to test the first ship in each new class so that improvements can be cost effectively applied to later ships of that class.

This project is needed because computer modeling and component testing on machines or in surrogates does not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366. The entire manned

submarine must be shock tested at sea. Shock tests have proven their value as recently as the Persian Gulf War when ships were able to survive battle damage and continue their mission because of ship design, crew training, and survivability lessons learned during previous shock tests.

The SEAWOLF was christened in June 1995 and is expected to be delivered to the Navy in the summer of 1996. Sea trials will begin about three months before delivery to the Navy, and shakedown (operational) tests and trial operations will be conducted on the ship for about a year. Because of the long series of initial tests, shock testing cannot occur before April 1997. Shock testing must be completed before October when unfavorable weather conditions are more likely occur and prior to the ship's scheduled Post Shake Down Availability scheduled to begin following the shock test in 1997. During this availability, the ship will be thoroughly inspected prior to unrestricted fleet operations in 1998.

1.3 PROPOSED ACTION

The proposed action described in this DEIS is to shock test the SEAWOLF submarine at an offshore location. The DEIS analyzes in detail alternative areas offshore of Mayport, Florida and Norfolk, Virginia (**Figure 1-1**). Details of the proposed action are presented in Section 2.2. The proposed action includes mitigation to minimize risk to marine mammals and turtles, as described in Section 5.0.

The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity. This approach would ensure that the maximum shock intensity goal is reached in a safe manner. A 4,536 kg (10,000 lb) charge is selected to ensure that the entire submarine is subjected to the desired level of shock intensity; the use of smaller charges would require many more detonations to excite the entire ship to the desired shock intensity level.

The series of five detonations would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems prior to the submarine experiencing the next level of shock intensity. The series of detonations would occur sometime between 1 April and 30 September 1997. If the Mayport area, the preferred alternative, is selected, the shock tests would be conducted between 1 May and 30 September 1997 to minimize risk to sea turtles, which are more abundant at the Mayport area during April.

1.4 BASIS FOR PREPARING THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

The DEIS was prepared in accordance with Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions;" the National Environmental Policy Act (NEPA) of 1969; the regulations implementing NEPA issued by the Council on Environmental Quality (CEQ), 40 Code of Federal Regulations (CFR) Parts 1500-1508; and Navy regulations implementing NEPA procedures (32 CFR 775). NEPA sets out the procedures Federal agencies must follow in analyzing environmental impacts of major Federal actions within U.S. territory. Executive Order 12114 sets out the procedures Federal agencies must follow in analyzing environmental impacts of major Federal actions occurring outside U.S. territory in the global commons or within the territory of another

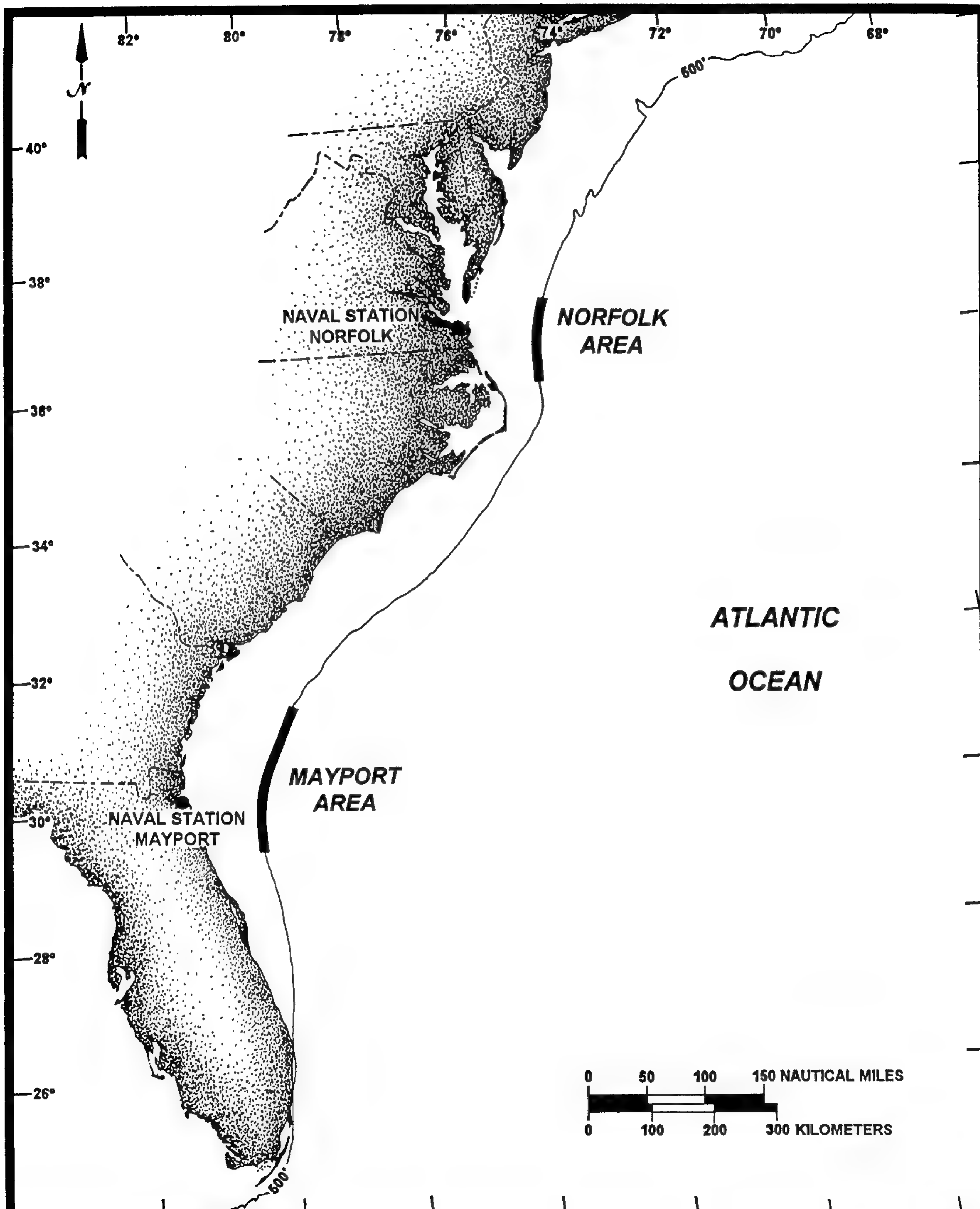


Figure 1-1. Location of the Mayport and Norfolk areas for SEAWOLF shock testing.

nation. Executive Order 12114 is based upon the independent authority of the President, not the statutory authority of NEPA. It furthers the purposes of NEPA but is not governed by CEQ regulations.

While NEPA and Executive Order 12114 represent two distinct, independent processes, the Navy has conducted the analysis under these two processes concurrently for the proposed shock testing of the USS SEAWOLF because the proposed action includes operations that would occur both within and outside U.S. territorial seas. Shock testing and associated mitigation operations would occur in offshore waters well outside of territorial seas. The only operations that would occur within territorial seas are shore support activities and vessel and aircraft movements in territorial waters (i.e., transits between the shore base and the offshore shock testing location). Shore support activities and vessel and aircraft movements are part of the routine operations associated with the existing shore bases and would not involve any unusual or extraordinary activities. Impact discussions in this DEIS (Section 4.0, Environmental Consequences) are divided into separate subsections to distinguish between those operations that are evaluated under NEPA and those that are evaluated under Executive Order 12114.

1.5 PUBLIC INVOLVEMENT

During the preparation of this Environmental Impact Statement, two major opportunities for public involvement were planned.

First, there was "scoping," the early and open process for identifying issues to be addressed in the DEIS. To begin the scoping process for this DEIS, a Notice of Intent was published in the *Federal Register* and five local newspapers (*Washington Post*, *Virginian Pilot*, *Florida Times Union*, *Beaches Leader*, and *Southeast Georgian*) during March 1995. It was also sent to federal, state, and local elected officials and agency representatives, and other interested parties. The Notice of Intent explained how to submit oral and written comments.

Three public scoping meetings were held during March 1995 to explain the project and allow the public to voice their concerns. Meeting dates, locations, number of attendees, and number of comments received are listed below:

- 23 March 1995 — National Oceanic and Atmospheric Administration auditorium at 1301 East West Highway, Silver Spring, Maryland. Nine people attended. No oral or written comments were received.

- 28 March 1995 — Granby High School Auditorium, 701 Granby Street, Norfolk, Virginia. Two people attended. No oral or written comments were received.

- 29 March 1995 — Mayport Middle School cafeteria, 2600 Mayport Road, Atlantic Beach, Florida. Nineteen people attended, and five provided oral comments.

In addition to the comments received during the public meetings, 13 written responses were received by the end of the comment period on 1 May 1995. The public

meeting and written comments were reviewed to make sure that all issues would be addressed in the DEIS. **Table 1-1** lists the issues identified from the public meeting and written comments, along with the corresponding sections in the DEIS where each concern is addressed.

The second major opportunity for public participation will be the publication of this DEIS. The Navy has filed it with the Environmental Protection Agency (EPA), which published a notice in the *Federal Register* announcing the availability of the DEIS and describing procedures for submitting comments. The Navy also distributed the DEIS to interested persons for review and comment (see Appendix A). The Navy will host public meetings in Norfolk, Virginia and Atlantic Beach, Florida to receive oral and written comments. Written comments will also be received for at least 45 days after the notice of the DEIS appears in the *Federal Register*.

Oral and written comments on the DEIS will be addressed in the Final EIS (FEIS), where appropriate. When the FEIS has been produced, a notice of availability will be published in the *Federal Register* which will start a 30-day public review period. The Navy will distribute the FEIS to interested persons for review and comment. After closure of the public review period, the Navy will issue its Record of Decision (ROD) for publication in the *Federal Register*.

1.6 FORMAT OF DRAFT ENVIRONMENTAL IMPACT STATEMENT

The DEIS follows the format specified by Navy regulations (32 CFR 775). The document is issue-oriented, providing greater analytical detail on more significant concerns and less information on other topics. The DEIS contains the following major sections:

- Executive Summary — gives an overview of the document and its findings;
- Introduction — explains the project purpose and need, the public participation process, and the format of the DEIS;
- Alternatives — discusses alternatives including "no action," the proposed action, and alternative areas for the proposed action; compares alternatives and selects a preferred alternative;
- Existing Environment — describes the physical, biological, and socioeconomic characteristics of the environment that might be affected by shock testing;
- Environmental Consequences — analyzes potential impacts of shock testing on the physical, biological, and socioeconomic environment;
- Mitigation and Monitoring — describes measures to avoid, minimize, or reduce environmental impacts; and
- Other sections and appendices — as listed in the Table of Contents.

Table 1-1. Issues identified from public scoping meetings and written comments. Section numbers indicate where responses are located in the Draft Environmental Impact Statement (DEIS).

Issue	DEIS Section
ATLANTIC BEACH PUBLIC SCOPING MEETING	
Need for the SEAWOLF	1.1
Groton, Connecticut as offshore test area	2.2.2.1
Avoiding harm to all marine species	2.2.3; 5.0
Marine mammal surveys and mitigation	3.2.3; 5.0
Marine fishes, particularly sport fishes	3.2.2; 3.3.1; 4.2.2.2; 4.2.3.1
Decibels and sound travel	4.1.1; Appendix E
PUBLIC SCOPING LETTERS	
Purpose and Need, Alternatives	
Need for shock testing	1.1, 1.2
No action alternative (HSUS)	2.1
Computer simulation alternative	1.1, 1.2, 2.1
Laboratory testing alternative	1.1, 1.2, 2.1
Shock test in the Florida Keys (FEOG)	2.2.2.1
Groton, Connecticut as offshore test area (HR)	2.2.2.1
Combining east and west coast shock tests (CCC)	2.2.2.1
Other alternative areas (HSUS)	2.2.2.1
Testing in waters where previous tests were conducted	2.2.2.1
Mitigation	
Mitigation for whales and turtles (FDCA, FDEP)	2.2.3; 5.0
Mitigation for endangered and threatened species (HSUS)	2.2.3; 5.0
Detonation delay if whales or turtles present (FDCA, FDEP)	2.2.3; 5.0
Warning blast prior to detonation (FDCA, FDEP)	5.0
Scheduling to avoid high turtle densities at Mayport (FDCA, FDEP)	2.2.3; 5.0
Aerial surveys before/after detonations (FDCA, FDEP, FEOG)	2.2.3; 5.0
Choosing an area with low density of marine life (HSUS)	2.2.2.2; 2.2.3; 2.3; 2.4
Mitigation to reduce impacts to all marine species (HR, HSUS)	2.2.2.2; 2.2.3; 5.0
Avoiding reef communities (GDNR)	2.2.2.2

Table 1-1. (Continued).

Issue	DEIS Section
Affected Environment	
Population numbers and status of marine species (HSUS)	3.2; Appendix B
Presence of whale adults and calves (FDCA, FDEP)	3.2.3; Appendix B
Sea turtle nesting habitat and timing (FDCA, FDEP)	3.2.4; Appendix B
Timing of adult and hatchling turtles to ocean (FDCA, FDEP)	3.2.4; Appendix B
Hatchling turtles associated with *Sargassum* (GDNR)	3.2.4; Appendix B
Spatial/temporal use of area by marine species (GDNR)	3.2; Appendix B
Spatial/temporal occurrence of demersal fisheries (GDNR)	3.2.5.2; 3.3.1
Spawning aggregations and intense schooling (GDNR)	3.2.2; 4.2.2.2
Possible presence of migratory fish during testing	3.2.2; 4.2.2.2
Potential Impacts	
Potential impacts to right and other whales (FDCA, FDEP)	4.2.2.3; 5.0
Potential impacts to sea turtles (FDCA, FEOG)	4.2.2.4; 5.0
Immediate and long-term impacts on biological communities (GDNR)	4.2.2
Physiological/behavioral reactions to detonations/sounds (HSUS)	4.2.2; Appendices D, E
Potential impacts to the seafloor and benthos	4.2.1.1; 4.2.2.5
Potential impacts to fish and fishery resources (FDCA, FEOG, FDOC)	4.2.2.2; 4.2.3.1
Creation of "dead zone" for fishing and sea life	4.2.2; 4.2.3.1
Impacts to commercial and recreational fishing (GDNR)	4.2.3.1
Trash, sludge, dead fish on beaches affecting tourism (FDCA, FDOC)	4.1.3
Indirect economic impacts to fishing/cruise industries (FDCA, FDOC)	4.1.3, 4.2.3
Conflicts with shipping, international sea traffic (FDCA, FDOC)	4.2.3.2
Other Issues	
Adequate public review period (HSUS)	1.5
Potential for nuclear contamination	Appendix F
Clarify required water depth (GDNR)	2.2.2.1
Gulf Stream effects on anchoring and test procedures (GDNR)	2.2.2.1
Florida coastal management program consistency (FDCA, FDEP)	11.7

CCC = California Coastal Commission
FDCA = Florida Department of Community Affairs
FDEP = Florida Department of Environmental Protection
FDOC = Florida Department of Commerce
FEOG = Florida Executive Office of the Governor
GDNR = Georgia Department of Natural Resources
HR = House of Representatives (Tillie K. Fowler)
HSUS = Humane Society of the United States

2.0 ALTERNATIVES

Alternatives for meeting the project purpose and need are described and evaluated in this section. The alternatives are (1) no action and (2) shock testing the SEAWOLF at an offshore location. Alternative offshore areas for shock testing are compared from operational and environmental perspectives. A preferred alternative has been identified based on these comparisons.

As discussed in Section 1.1, the SEAWOLF LFT&E program already includes the maximum reasonable amount of computer modeling and component testing. Therefore, computer modeling and component testing are not reasonable stand-alone alternatives to shock testing. Instead, they are considered part of the "no action" alternative.

2.1 NO ACTION

Under this alternative, no new activities affecting the physical environment would be conducted to predict the response of SEAWOLF class submarines to underwater detonations. This alternative would avoid all environmental impacts of shock testing.

As described in Section 1.1, the Navy has established a Live Fire Test & Evaluation (LFT&E) program to demonstrate the survivability of SEAWOLF class submarines. The program consists of three major areas which together provide the data necessary to assess the SEAWOLF's survivability: computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. The SEAWOLF LFT&E program already includes the maximum reasonable amount of computer modeling and component testing. Only by testing the entire ship manned with the appropriate systems operating can the shock response of the entire ship, including the interaction of ship systems and components, be obtained and an adequate assessment of the survivability of the submarine be determined in accordance with 10 USC 2366. The intent of 10 USC 2366 is to ensure that the combat survivability of the weapon system (submarine) is assessed before the system is exposed to hostile fire. The information obtained during the shock test is used to improve the shock resistance of the ship and therefore reduce the risk of injury to the crew. The "no action" alternative would prevent the Navy from being able to make the survivability assessment required by 10 USC 2366.

As the "no action" alternative involves no activity affecting the physical environment, it is not individually analyzed further in the DEIS. The "no action" alternative is implicit in the environmental analysis throughout the document. The Existing Environment section provides a "no action" benchmark against which the proposed action can be evaluated. The Environmental Consequences section compares impacts of an action (shock testing) with the alternative of "no action."

2.2 SHOCK TESTING THE SEAWOLF AT AN OFFSHORE LOCATION

2.2.1 Description of Testing

The remaining alternative discussed is the proposed action, which is to shock test the SEAWOLF at an offshore location. The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity. The series of five detonations would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems prior to the submarine experiencing the next level of shock intensity. The series of detonations would occur sometime between 1 April and 30 September 1997. If the Mayport area is selected, there would be no testing in April, when turtle densities are highest at that area (see Section 2.2.3.1).

The test site would be selected from within a general "area" such as the Mayport and Norfolk areas described later in this section. Once the general area is selected, the final specific site for shock testing would be selected 2 to 3 days before the test, based on marine mammal and turtle surveys (see Section 2.2.3.2). The operational site for testing would be a 1.85 km (1 nmi) diameter zone centered on the explosive charge (**Figure 2-1**). An exclusion zone of 9.3 km (5 nmi) radius would be established around the detonation point to exclude all non-test ship, submarine, and aircraft traffic.

Prior to the shock test, the submarine would be examined, configured, and prepared to accommodate the shock testing equipment. The pre-test status of each ship compartment would be documented. Shore support and facilities (see below) would be readied, and the crew would be trained for the test.

For shock testing, an operations vessel would moor in a water depth of 152 m (500 ft) at the test site. Test personnel would deploy a one-mile long test array (**Figure 2-1**). The array would consist of an explosive charge placed about 30 m (100 ft) below the water surface, marker buoys, instrumentation, connecting ropes, and the "gate", a small diameter rope that the submarine would break as it passes through the array. For each test, the submarine would submerge about 20 m (65 ft) below the water surface and navigate toward the marker buoys located on each side of the gate. As the submarine passes through the gate, the explosive would be detonated from the operations vessel. The submarine would then surface, and after an initial inspection for damage, travel back to the shore facility for post-test inspections and preparations for the next test. For each subsequent test, the gate would be moved closer to the explosive so the submarine experiences a more severe shock.

A conventional Navy explosive (High Blast eXplosive, HBX-1) would be used for each shock test. HBX-1 consists of the following components (by weight): cyclotrimethylene trinitramine - 39.32%; trinitrotoluene - 37.76%; aluminum powder - 17.10%; wax - 4.57%; and miscellaneous fillers - 1.25%. The charge would be held in a cylindrical steel container measuring 1.5 m (5 ft) in diameter by 1.7 m (5.6 ft) long with a total weight of 1,297 kg (2,860 lb) in air. The largest possible fragment from the explosion that would settle to the seafloor would be the top plate and crossbar which together weigh 204 kg (450 lb). After detonation, the test array would be recovered and floats and rigging debris would be removed.

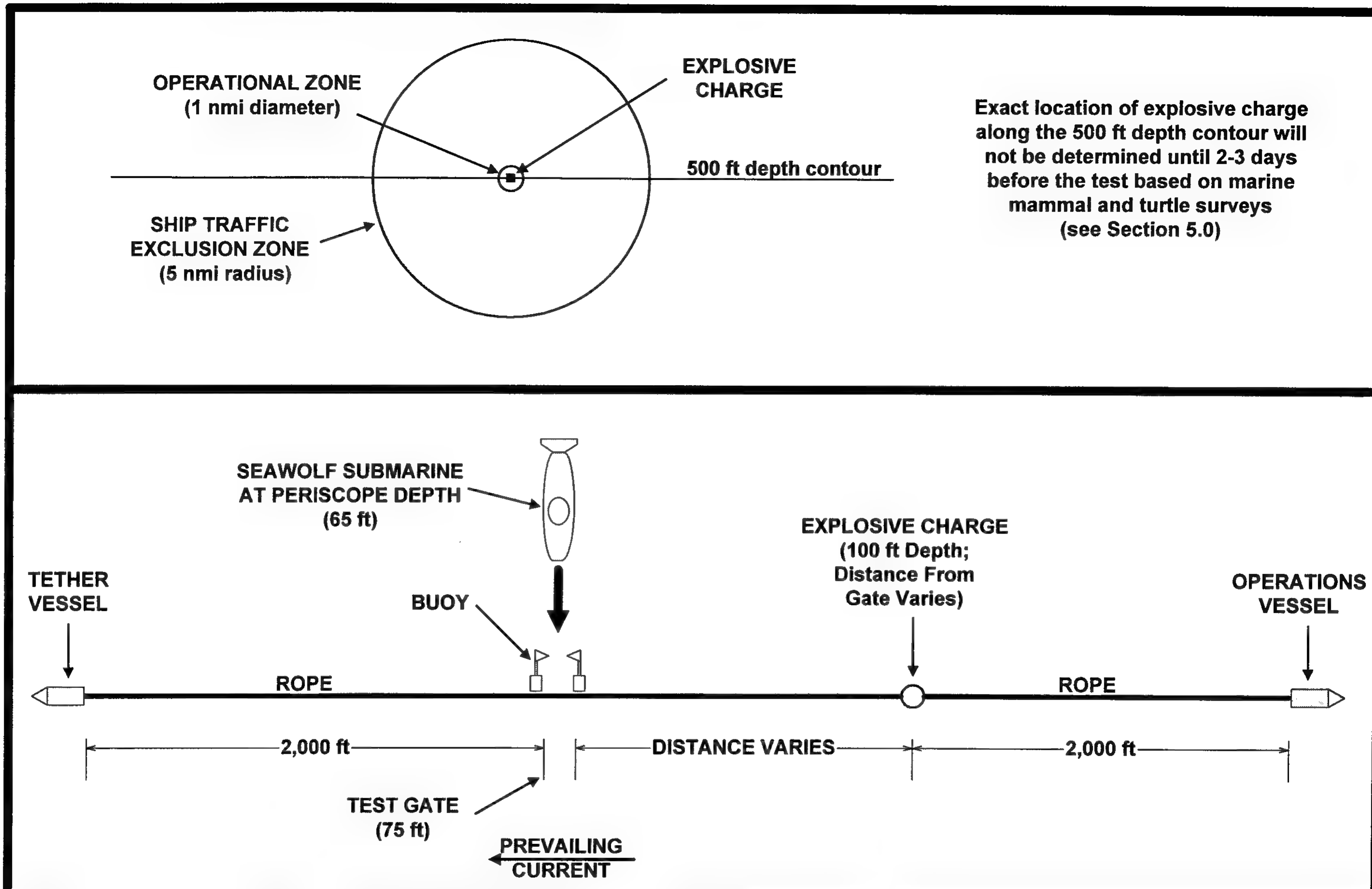


Figure 2-1. Test array, operational zone, and ship traffic exclusion zone for SEAWOLF shock testing.

Shore support for the SEAWOLF Ship Shock Test Team would consist of five to six rented trailers (temporary facilities) in an office configuration with water closet, wash basin, and air conditioning. Each trailer would have electric power, telephone service, a few desks, a bottled water dispenser, and probably word processors or personal computers. Type of sewerage service would depend upon the layout of the base's facilities, i.e., directly into base lines or pumped out by truck. In addition, there would be an instrumentation trailer and possibly a small supply trailer (cable, spare parts, etc.). Additional space would be leased outside the base, if required. The Shock Test Explosives Operations Team would have expendables such as rope, rigging materials, and floats stored on shore to replenish what is used for each shot. Pilferable materials would be secured in two milvans on shore.

2.2.2 Alternative Areas

Several possible general areas for shock testing were evaluated by the Navy, as described below. The final, specific site for shock testing would not be selected until 2 to 3 days before the test based on marine mammal and turtle surveys (see Section 2.2.3.2). However, the Navy has identified general offshore "areas" which meet certain operational criteria, and has a preferred area. The final test site would be selected within the preferred area if this alternative is selected.

2.2.2.1 Operational Requirements

A location on the east coast would best meet operational needs because that is where the SEAWOLF will be homeported and where all sea trials will occur. Scheduling the test on the west coast or in the Gulf of Mexico would increase the time the ship is away from the homeport, complicate or prolong repairs, and further delay deployment. Under Navy Personnel Tempo (PERSTEMPO) regulations, a ship is required to spend a day in homeport for every day it is away from homeport for purposes of crew quality of life and efficiency (OPNAVINST 3000.13A, 21 December 1990). A shock test conducted away from the homeport is typically a 3½ to 4 month deployment, including time spent having special equipment installed at the shore support facility, completing test runs and training, and conducting the actual shock testing. Scheduling the test away from the east coast would maximize time spent away from the homeport and minimize the SEAWOLF's availability for deployment as part of fleet resources.

The Navy screened possible east coast shock testing areas according to operational criteria. Potential areas were first defined as locations having a water depth of 152 m (500 ft) that are within 185 km (100 nmi) of a naval station support facility and a submarine repair facility. This water depth is sufficient to minimize the effect of a bottom reflected pressure wave on the submarine and shallow enough to allow mooring of the operations vessel with the test array. This depth would also permit recovery of the crew and submarine in the unlikely event of a control failure. Other criteria include proximity to an ordnance storage/loading facility and Navy assets (ships and aircraft) necessary to support the test needs. There must also be little or no shipping traffic in the area. Finally, calm seas and good visibility are needed for the test, so a location that has a preponderance of such is needed. The rationale for each of these operational requirements is explained in separate subsections below.

Five east coast areas were identified that could potentially meet the Navy's operational requirements: Mayport, Florida; Norfolk, Virginia; Groton, Connecticut; Charleston, South Carolina; and Key West, Florida. Charleston was eliminated because of the closure of the Charleston Navy Yard and Charleston Naval Station under the Base Closure and Realignment (BRAC) process (i.e., facilities and vessels to support the test would not be available). The water depth of 275 m (900 ft) at the Key West area is too great for the planned shock testing. In addition, the Key West area lacks the industrial base to support submarine repairs or drydocking, and there is no surface vessel homeport nearby which could provide Navy assets (ships and planes) to support the test.

The following sections evaluate the remaining three areas (Mayport, Norfolk, and Groton) according to the Navy's operational criteria. A summary and comparison is presented after the individual criteria have been discussed.

Proximity to Naval Station Support Facility

A Naval Station which can provide limited maintenance and depot level support for submarines (e.g., tradespeople, spare parts, cranes) must be located near the test site to repair/replace damaged equipment and systems. A reasonable distance is 185 km (100 nmi), which would allow a 20- to 24-hr transit time for the SEAWOLF (assuming the submarine is surfaced and traveling at a speed of about 4 to 5 kt).

All three remaining areas are within 185 km (100 nmi) of a shock test support facility. For the Mayport area, the support facility would be the Naval Submarine Base Kings Bay, with distances ranging from to 139 to 185 km (75 to 100 nmi). For the Norfolk area, the support facility would be Naval Station Norfolk, with distances ranging from 148 to 185 km (80 to 100 nmi). For the Groton area, the support facility would be New London Submarine Base, with distances ranging from 167 to 185 km (90 to 100 nmi).

Proximity to Submarine Repair Facility

Close proximity to a submarine repair facility is imperative for the SEAWOLF shock test. A repair facility must be nearby to provide drydocking, special trades, equipment, and materials to perform post-test inspections and prepare for the next test. A reasonable distance between the repair facility and the test site is 185 km (100 nmi), which would allow a 20- to 24-hr transit time for the SEAWOLF (assuming the submarine is surfaced and traveling at a speed of about 4 to 5 kt).

If testing occurred offshore of Mayport, then the Naval Submarine Base Kings Bay would serve as the repair facility. Distances to the repair facility range from 139 to 185 km (75 to 100 nmi). If testing occurred offshore of Norfolk, then the Norfolk Naval Shipyard would serve as the repair facility; distances to the repair facility range from about 148 to 185 km (80 to 100 nmi). If Groton were selected, the shipbuilder's yard in Groton could be used for repairs. Distances range from about 167 to 185 km (90 to 100 nmi).

Proximity to Ordnance Storage/Loading Facility

Prior to each test, an explosive would be loaded onto the operations vessel at an ordnance storage/loading facility. The facility must have qualified personnel and equipment to handle the explosives and must be located within about 370 km (200 nmi), which allows a 20- to 24-hr transit at 8 to 10 kt. Greater distances could increase the time to prepare for the next test and preclude windows of opportunity to test on weather-favorable days.

All three areas are within 370 km (200 nmi) of ordnance storage/loading facilities. If the Mayport area is selected, then explosives would be stored and loaded either at the Naval Weapons Station in Charleston, South Carolina, a distance of 185 to 370 km (100 to 200 nmi); or at Naval Station Mayport, a distance of 117 to 185 km (63 to 100 nmi). For testing offshore of Norfolk, explosives would be stored and loaded at the Naval Weapons Station in Yorktown, Virginia, a distance of about 185 to 222 km (100 to 120 nmi). If Groton were selected, then the explosives would be stored and loaded at the Naval Weapons Station in Earle, New Jersey, about 195 to 287 km (105 to 155 nmi) away.

Availability of Navy Assets

Navy ships would be needed at the test site to monitor, divert, and escort non-test vessels away from the exclusion zone, provide communications, track the SEAWOLF, and perform other tasks. Airplanes and helicopters would serve as observation and photographic platforms before, during, and after the test and would also be available for emergency response and rescue. For sufficient vessels and aircraft (and alternates) to be available, a large Navy installation must be within 185 km (100 nmi) of the test site. This would allow a 8- to 10-hr transit time for support craft steaming at 10 to 12 kt. The distance would also allow each support aircraft to remain on-site for about 3 to 3½ hr, with an adequate fuel reserve for safety.

The availability of Navy assets is an important consideration given the need for a variety of Navy vessels and aircraft for shock test support. In recent years, obtaining Navy assets (both air and surface) has become increasingly difficult as both the budget and the size of the Navy have decreased. Supporting a shock test reduces fleet assets available to meet the other mission goals of the Atlantic Fleet. Therefore, to minimize transit times and make the most effective use of Navy assets, it is imperative that the SEAWOLF shock testing be conducted at a location which is close to a large Navy installation with available ships and aircraft to support the test.

Because large Navy installations are located at Mayport, Florida, and Norfolk, Virginia, the Navy is in the best position to support shock testing at these two areas. Transit distances range from 117 to 185 km (63 to 100 nmi) for sites in the Mayport area and 148 to 185 km (80 to 100 nmi) for sites in the Norfolk area. Shock testing at Groton would be very difficult because there are no nearby Navy installations with the fleet operational assets required to support shock testing. The nearest Navy installations at Newport, Rhode Island and Staten Island, New York are now closed. Naval Station Philadelphia is also closed. Earle Naval Weapons Station in Colts Neck, New Jersey is homeport to only a few ships, none of which are of the type needed to support shock testing. Therefore, the nearest Naval Station which would have available assets to

support shock testing in the Groton area is Naval Station Norfolk, with distances ranging from 474 to 585 km (256 to 316 nmi).

Proximity to SEAWOLF Homeport

Proximity to New London, Connecticut is desirable because it is the proposed homeport for the SEAWOLF (Department of the Navy, 1995c). The Groton area is obviously closest to the SEAWOLF homeport, about 167 to 185 km (90 to 100 nmi). New London is about 1,250 to 1,482 km (675 to 800 nmi) from the Mayport area and about 555 to 675 km (300 to 365 nmi) from the Norfolk area.

Water Depth

A water depth of 152 m (500 ft) is sufficient to minimize the effect of a bottom reflected pressure wave on the submarine and shallow enough to allow mooring of the operations vessel with the test array. This depth would permit recovery of the crew and submarine in the unlikely event of a control failure.

All three areas satisfy the water depth requirement. That is, the areas were initially defined as all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of the shock test support facility.

Ship Traffic

An area with little or no ship traffic is preferred; established shipping and submarine transit lanes should be avoided. Ships passing near the shock test site could delay shock testing. An exclusion zone of 9.3 km (5 nmi) radius would be established around the test site to exclude all non-test ship, submarine, and aircraft traffic. Notices to Airmen and Mariners would be published in advance of each test. Any traffic entering an 18.5 km (10 nmi) radius around the detonation point would be warned to alter course or would be escorted from the site. Testing could be delayed while support vessels divert and escort the traffic away from the test site.

Any of the three areas would be acceptable from the standpoint of ship traffic. None are located in or near shipping lanes or submarine transit lanes. However, data from port authorities for ports near each location indicate that the Mayport area has about half as much commercial ship traffic as either the Norfolk or Groton areas (**Table 2-1**). The Groton area has the lowest density of military traffic, and the Norfolk area has the highest. Overall, the Mayport area is the most favorable and the Norfolk area is least favorable.

Weather and Sea State

Safe deployment, maintenance, and recovery of the test array, as well as effective mitigation, require good weather and sea conditions. Personnel on the operations vessel need a stable work platform while handling equipment and materials. Divers need calm seas to connect and reconnect the submarine "gate." Ideal test conditions are seas of 0.6 m (2 ft) or less, a light wind, and unlimited visibility. Conditions become marginal when seas approach 1.8 m (6 ft), winds approach 34 kph (21 mph), and

Table 2-1. Ship traffic levels near the Mayport, Norfolk, and Groton areas. Sources: Georgia Port Authority, Hampton Roads Maritime Association, Jacksonville Port Authority, and Maritime Association of New York. Mayport ship traffic includes 50% of the traffic destined for Savannah, Georgia.

Type of Ship Traffic	Mayport	Norfolk	Groton
Commercial Ship Traffic			
Ships per year	2,400	5,300	4,750
Ships per day	7	15	13
Military Ship Traffic Density	Moderate	High	Low

visibility is less than 9.3 km (5 nmi). In addition, a sea state of Beaufort 4 or less is required for visual observations of marine mammals and sea turtles during the pre-detonation monitoring (see Section 5.0).

Data from the Naval Oceanography Command (Department of the Navy, 1989) were used to evaluate the potential areas (**Table 2-2**). The data were available for three time intervals: March through May, June through August, and September through November. These intervals include the range of possible dates for the planned shock testing (1 April through 30 September).

Generally, the Mayport area has the highest probability of favorable conditions for most weather and sea state categories and time intervals. Conditions at the other two areas are similar with the exception of fog and visibility. Groton has a high incidence of fog (up to 26.6%) and low visibility during summer months, posing a significant operational safety risk which would result in testing delays.

Conclusions

Table 2-3 compares Mayport, Norfolk, and Groton according to the operational criteria. For each criterion (except for ship traffic and proximity to SEAWOLF homeport, which use ranks), the areas are scored on a scale of 0 to 4. Mayport and Norfolk have nearly identical totals (36 and 34, respectively), whereas Groton scores substantially lower (24). Groton scored poorly on criteria for incidence of fog and proximity to Navy assets (air and surface). The high incidence of fog and low visibility at Groton during summer months could result in frequent testing delays, reduce the effectiveness of mitigation measures, and pose safety problems for support vessels and aircraft. The lack of nearby Navy assets to support shock testing also makes this an unfavorable location from an operational perspective.

Table 2-2. Comparison of weather and sea state conditions at the Mayport, Norfolk, and Groton areas (Data from: Department of the Navy, 1989). The location having the most favorable percentage for each condition during each time period is shaded. Values that could result in frequent delays to shock testing are boxed with a thick line.

Weather/Sea State Condition	Percent Occurrence of Weather/Sea State Condition								
	Mar-May			Jun-Aug			Sep-Nov		
	Mayport	Norfolk	Groton	Mayport	Norfolk	Groton	Mayport	Norfolk	Groton
Ideal Conditions									
Seas ≤0.6 m (≤2 ft)	41.1	18.0	17.3	54.2	41.9	48.0	33.6	29.9	29.2
Visibility ≥18 km (≥10 nmi)	62.6	69.0	60.6	64.8	52.8	40.9	54.2	41.9	59.1
Marginal Conditions									
Seas ≤1.8 m (≤6 ft)	87.1	63.7	57.3	93.0	88.4	91.2	78.7	76.1	74.4
Wind ≤34 kph (≤21 mph)	94.7	85.3	78.7	95.7	96.0	97.1	82.6	83.1	86.4
Visibility ≥9.3 km (≥5 nmi)	97.2	94.8	90.8	96.8	90.1	76.2	97.9	94.3	91.8
Fog	0.4	8.0	15.0	0.1	3.5	26.6	0.2	2.3	7.9

Table 2-3. Evaluation of Mayport, Norfolk, and Groton areas according to operational criteria.

Criterion	Basis for Scoring	Scoring of Alternative Areas			Comments
		Mayport	Norfolk	Groton	
Facilities and Assets					
Shock test shore support facility within 185 km (100 nmi)	Portion of area meeting criterion: 0 = 0% 1 = 1-49% 2 = 50-74% 3 = 75-99% 4 = 100%	4	4	4	All areas are within 185 km (100 nmi) of a shock test support facility.
Submarine repair facility within 185 km (100 nmi)	(same as above)	4	4	4	All areas are within 185 km (100 nmi) of a submarine repair facility.
Ordnance storage/ loading facility within 370 km (200 nmi)	(same as above)	4	4	4	
Naval assets (surface) within 185 km (100 nmi)	(same as above)	4	4	0	Sources within 185 km (100 nmi) of Groton area are on base closure list.
Naval assets (air) within 185 km (100 nmi)	(same as above)	4	4	0	Sources within 185 km (100 nmi) of Groton area are on base closure list.
Proximity to SEAWOLF homeport	Rank, from farthest to nearest	1	2	3	Groton is proposed SEAWOLF homeport
Environmental Factors Affecting Operations					
Water depth of 152 m (500 ft)	Portion of area meeting criterion: 0 = 0% 1 = 1-49% 2 = 50-74% 3 = 75-99% 4 = 100%	4	4	4	By definition, all areas meet this requirement.
Ship traffic	Rank, from highest to lowest density	3	1	2	Mayport has about half as much commercial ship traffic as Norfolk or Groton. Norfolk has the highest density of military ship traffic.
Sea state [average occurrence of seas ≤1.8 m (≤6 ft)]	0 = <10% 1 = 10-24% 2 = 25-49% 3 = 50-75% 4 = >75%	4	4	3	
Incidence of fog (average)	0 = >15% 1 = 11-15% 2 = 6-10% 3 = 1-5% 4 = <1%	4	3	0	Groton has up to 26.6% incidence of fog during summer months, which could delay testing.
TOTAL SCORE (higher is better)		**36**	**34**	**24**	

In conclusion, Mayport, Florida and Norfolk, Virginia are the areas that meet all of the Navy's operational requirements. These two areas are the focus of detailed environmental analysis in this DEIS. **Figure 2-2** shows the Mayport area, which is located offshore of Georgia and northeast Florida. **Figure 2-3** shows the Norfolk area, which is located offshore of Virginia and North Carolina.

2.2.2.2 *Environmental Considerations at Mayport and Norfolk*

At both the Mayport and Norfolk areas, possible test sites were first defined as any point along the 152 m (500 ft) depth contour within 185 km (100 nmi) of a naval station support facility and a submarine repair facility. Environmental features near each area were mapped, including marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, and critical habitat for endangered or threatened species (Department of the Navy, 1995a). Buffer zones were developed to avoid impacts to these areas and associated biota. Portions of the 152 m (500 ft) depth contour were excluded as described below.

Marine Sanctuaries

There are no existing or proposed marine sanctuaries near the Mayport area. However, at the Norfolk area, a buffer zone was developed for the proposed Norfolk Canyon National Marine Sanctuary. Norfolk Canyon is the southernmost submarine canyon in a series of prominent deepwater features along the U.S. east coast. The Norfolk Canyon area proposed for National Marine Sanctuary designation provides habitat for a distinctive assortment of living marine resources, including two species of soft coral rarely encountered elsewhere.

The NMFS has recommended a buffer zone of 4.6 km (2.5 nmi) to protect the unique benthic fauna of the Norfolk Canyon area from the effects of the shock test (Appendix C). Therefore, all of the 152 m (500 ft) depth contour passing through the proposed sanctuary, as well as 4.6 km (2.5 nmi) buffers on either side, were excluded from the Norfolk area as potential test sites (**Figure 2-3**). Based on calculations presented in the Environmental Consequences section, this buffer zone is more than adequate to protect marine mammals, sea turtles, fish, and benthic fauna.

Artificial Reefs, Hard Bottom Areas, and Shipwrecks

Buffer zones were developed for artificial reefs, hard bottom areas, and shipwrecks to protect fish that congregate at these features. Calculations in the Environmental Consequences section show that over 90% of swimbladder fish would survive a 4,536 kg (10,000 lb) explosion if the fish were 1.85 km (1 nmi) from the detonation point. These calculations apply to fish near the surface; those near the bottom would be much less vulnerable at this distance. Therefore, a 1.85 km (1 nmi) buffer is considered more than sufficient to protect these features.

At the Mayport area, there are no known artificial reefs, hard bottom areas, or shipwrecks within 1.85 km (1 nmi) of the 152 m (500 ft) depth contour (Department of the Navy, 1995a). At the Norfolk area, there are no artificial reefs or hard bottom areas, but several shipwrecks exist in the northern part of the area. The entire portion of the area

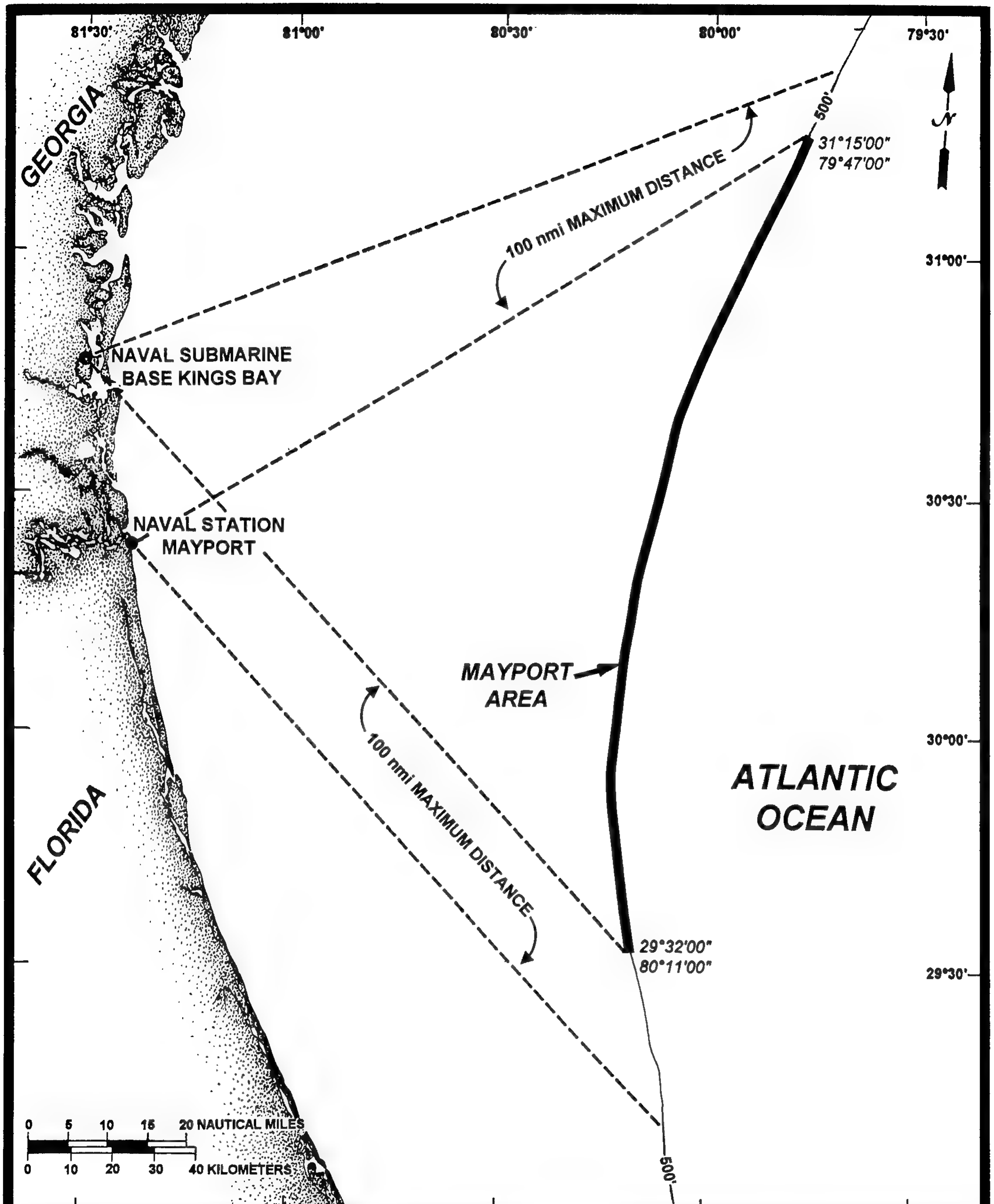


Figure 2-2. The Mayport area. The area includes all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of Naval Station Mayport and Naval Submarine Base Kings Bay.

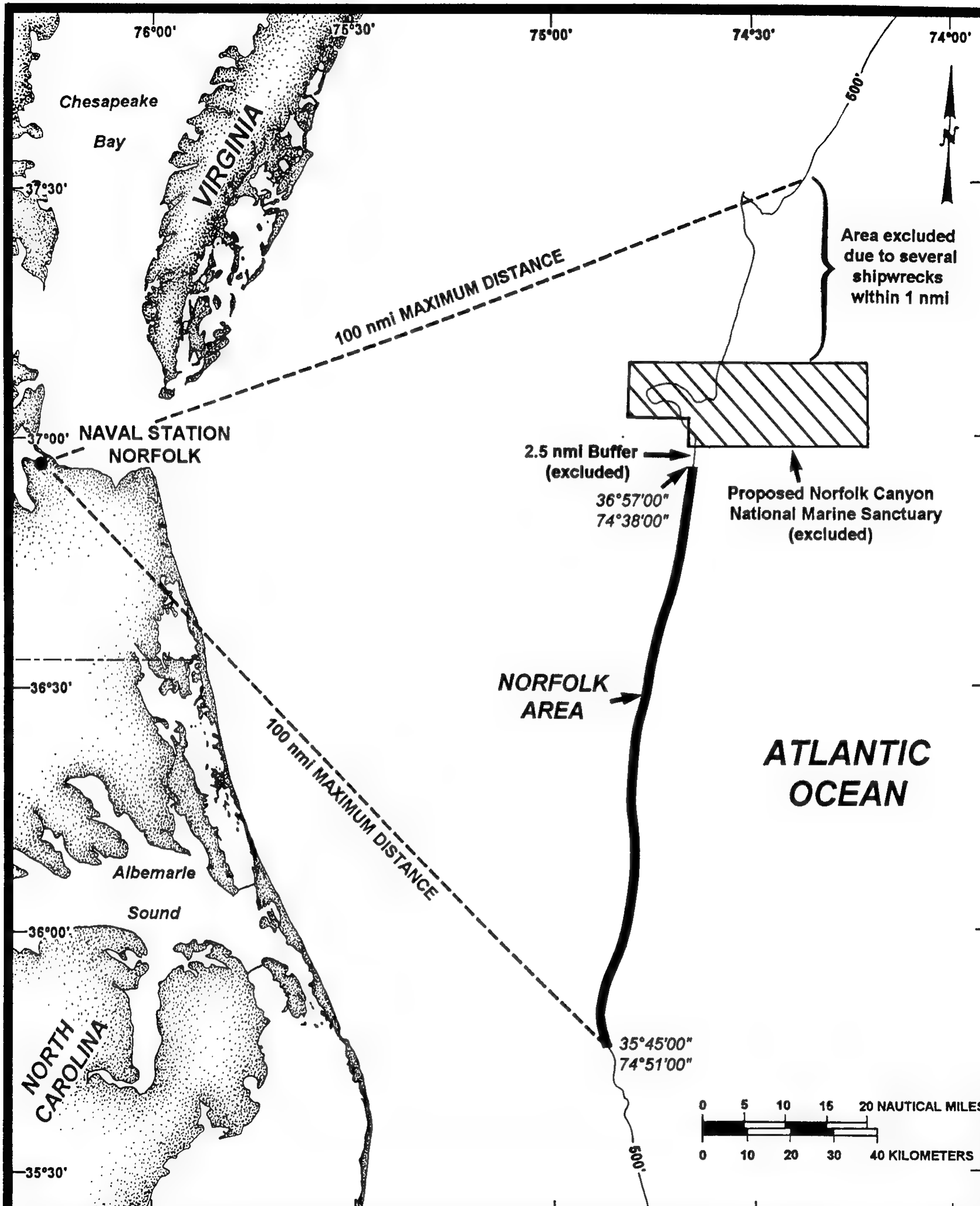


Figure 2-3. The Norfolk area. The area includes all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of Naval Station Norfolk, except the excluded areas indicated.

north of the proposed Norfolk Canyon National Marine Sanctuary was eliminated for this reason (**Figure 2-3**).

Ocean Disposal Sites

A buffer zone for ocean disposal sites was adopted to ensure that shock testing does not conflict with any ongoing disposal activities. An appropriate buffer zone for ocean disposal sites is 18.5 km (10 nmi), which is the radius within which all ship traffic would be warned to alter course or be escorted from the site. There are no ocean disposal sites within 18.5 km (10 nmi) of either the Mayport or Norfolk area (Department of the Navy, 1995a).

Critical Habitat

Based on information received from the NMFS (Appendix C), critical habitat for one endangered species, the northern right whale, exists near Mayport. No critical habitat for other endangered or threatened marine mammals or sea turtles exists within or near the Mayport or Norfolk area.

The right whale critical habitat is located along the northeast Florida coast well inshore of the Mayport area (see Appendix B, Figure B-1). The distance between the Mayport area and the right whale critical habitat ranges from 76 to 115 km (41 to 62 nmi), greatly exceeding the buffer zones for marine mammals (3.79 km or 2.05 nmi) and swimbladder fish (1.85 km or 1 nmi). As discussed in the Environmental Consequences section, other marine organisms (such as zooplankton upon which right whales feed) are more resistant to explosions and would be more than adequately protected by a 1.85 km (1 nmi) buffer. More importantly, because of their seasonal migrations, right whales are not expected to be present within the Mayport critical habitat area after late March. During the May through September period proposed for shock testing, most right whales are found feeding north of Cape Cod (Kraus et al., 1993). This finding is further supported by the aerial surveys conducted over the Mayport area; no northern right whales were identified during the six month period from April through September (Department of the Navy, 1995b).

Conclusions

At the Mayport area, there are no marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, or critical habitat areas within the buffer zones allocated for these features. Therefore, all points along the 152 m (500 ft) depth contour are considered potential shock testing sites (**Figure 2-2**).

At the Norfolk area, the portion of the 152 m (500 ft) depth contour passing through the proposed Norfolk Canyon Marine Sanctuary, along with a 4.6 km (2.5 nmi) buffer on either side, was excluded. The entire area north of the proposed sanctuary was eliminated due to the presence of several shipwrecks within a distance of 1.85 km (1 nmi). All remaining points along the 152 m (500 ft) depth contour are considered potential shock testing sites (**Figure 2-3**).

2.2.3 Mitigation Measures

The proposed action includes mitigation designed to minimize risk to marine mammals and turtles. Mitigation measures include (1) a schedule shift at Mayport (no testing in April to avoid higher densities of sea turtles); and (2) a detailed marine mammal and sea turtle mitigation plan that includes site selection and pre- and post-detonation monitoring. The marine mammal and sea turtle mitigation plan is summarized below and described in more detail in Section 5.0. Other mitigation measures include an exclusion zone to avoid impacts to routine vessel and air traffic, and measures to deal with unexploded ordnance in the unlikely event of a misfire.

2.2.3.1 Schedule Shift to Avoid High Turtle Densities at Mayport

Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September 1997. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995, as explained in Section 3.2.4. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

2.2.3.2 Marine Mammal and Sea Turtle Mitigation Plan

A detailed Marine Mammal and Sea Turtle Protection/Mitigation Plan is presented in Section 5.0. The plan includes the same type of mitigation and monitoring efforts that were used successfully during the shock trial of the USS JOHN PAUL JONES in 1994 off the coast of southern California where marine mammal population densities are significantly greater than either the Norfolk or Mayport areas. Those shock trial operations included two 4,536 kg (10,000 lb) detonations and resulted in no deaths or injuries of marine mammals (Naval Air Warfare Center, 1994). The mitigation plan for SEAWOLF shock testing would similarly avoid impacts and minimize risk to marine mammals and sea turtles in three main ways:

- **Site selection**. Initial, general site selection would be based on operational requirements and surveys. Within the general area selected for the shock test (e.g., Mayport or Norfolk), aerial surveys would be conducted to select a small test site having the fewest marine mammals and turtles. Results of a survey three weeks prior to the shock test would be used to select a single primary test site and two secondary test sites. One of these would be selected as the final test site based on aerial survey 2 to 3 days before each detonation.

- **Pre-detonation monitoring**. In the hours before each test, aerial and shipboard observers would search for marine mammals and turtles at the test site. Passive acoustic surveys would also be used to detect marine mammal calls. If any marine mammal or sea turtle were detected within the safety range of 3.79 km (2.05 nmi) radius around the detonation point, testing would be postponed. Detonation would not occur until there are no marine mammals or turtles detected within the safety range.

- **Post-detonation monitoring**. After the explosion, aerial and shipboard observers would survey the test site. A Marine Animal Recovery Team led by a marine mammal veterinarian would attempt to recover and treat any injured animals. If the survey showed that marine mammals or turtles were killed or injured, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

2.2.3.3 *Vessel Exclusion Zone*

An exclusion zone of 9.3 km (5 nmi) radius would be established around the detonation point to exclude all non-test ship, submarine, and aircraft traffic. Any traffic within an 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the site. Notices to Airmen and Mariners would be published in advance of each test. An immediate HOLD on the test would be ordered if any unauthorized craft entered the exclusion zone and could not be contacted. The HOLD would continue until the exclusion zone was clear of unauthorized vessels. The size of the exclusion zone is necessary for operational security and to allow large vessels sufficient time to change course. It is also intended to minimize broad-band noise from ship engines, which could interfere with passive acoustic monitoring for marine mammals.

2.2.3.4 *Unexploded Ordnance*

The probability of a charge not detonating during a test is remote. Should a charge fail to explode, the Navy would attempt to identify the problem and detonate the charge (with all mitigation measures in place as summarized above). If these attempts failed, the Navy would recover the explosive and disarm it. Only in case of an extreme emergency or to safeguard human life would the Navy dispose of the charge at sea.

2.3 COMPARISON OF ALTERNATIVES

Table 2-4 summarizes the analysis of alternatives with respect to project purpose and need, operational criteria, and environmental impacts. The "no action" alternative (including computer modeling and component testing) is not a reasonable alternative because it would not provide the information and data necessary to support an assessment of the survivability of the ship as required by 10 USC 2366. The "no action" alternative was not analyzed further, although a "no action" alternative is implicit in the environmental analysis throughout the document.

Table 2-4. Summary of alternatives analysis.

Basis for Comparison	Alternative			
	No Action (Includes Maximum Reasonable Amount of Computer Modeling and Component Testing)	**Shock Testing at an Offshore Location**		
		Groton Area	Mayport Area	Norfolk Area
Meets project purpose and need	No	Yes	Yes	Yes
Meets operational criteria	No further analysis (alternative does not meet project purpose and need)	No	Yes	Yes
Potential environmental impacts	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	Less risk of impacts to marine mammals at Mayport. Other impacts similar at the two areas. **See Table 2.5 and Table 2.6 for details.**	

Alternative areas for the proposed shock testing of the SEAWOLF were evaluated by the Navy according to operational criteria. A location on the east coast would best meet operational needs because that is where the SEAWOLF will be homeported and where all sea trials will occur. Three east coast areas (Mayport, Norfolk, and Groton) were compared in detail with respect to operational criteria including proximity to a shock test support facility, submarine repair facility, ordnance storage/loading facility, and Navy assets, as well as environmental factors such as water depth, ship traffic, and weather/sea state. The analysis showed that the Mayport and Norfolk areas meet all of the Navy's operational requirements and are rated as nearly equal (**Table 2-3**).

Potential environmental impacts of shock testing at the Mayport and Norfolk areas are analyzed in the Environmental Consequences section of the DEIS and summarized in **Table 2-5**. **Table 2-6** presents further details concerning marine mammals and turtles at the two areas.

Most environmental impacts of shock testing would be similar at Mayport or Norfolk (**Table 2-5**). These include minor and/or temporary impacts to the physical and biological environments and existing human uses of the test site. However, the two areas differ significantly with respect to potential impacts on marine mammals, as discussed below.

The risk of impacts to marine mammals would be much lower at Mayport than at Norfolk (**Table 2-6**). At either area, mitigation methods described in Section 5.0 would result in selection of a small test site with very low densities of marine mammals. In addition, most marine mammals would be detectable during pre-detonation aerial surveys, surface observations, and passive acoustic monitoring, minimizing the risk of death or injury. However, because of the difference in marine mammal densities between areas, the number of marine mammals potentially killed, injured, or experiencing acoustic discomfort would be about eight times lower at Mayport than at Norfolk. Mitigation would be about equally effective at the two areas (93%).

Potential impacts to sea turtles also differ between areas, but not as much as for marine mammals. With the month of April excluded from testing at Mayport, the number of turtles potentially killed, injured, or experiencing acoustic discomfort would be about the same at either area (**Table 2-6**). Sea turtle mitigation would be equally effective at both areas because one species (the loggerhead sea turtle) accounts for most of the population at both areas. Mitigation would be much less effective for sea turtles than for marine mammals because sea turtles are relatively small, do not swim in groups, are rarely on the surface, and do not make sounds.

In conclusion, the most significant environmental difference between the areas is the much lower risk of impacts to marine mammals at the Mayport area. Considering all components of the physical, biological, and socioeconomic environment, potential impacts would be less at the Mayport area.

Table 2-5. Comparison of potential environmental impacts of shock testing at the Mayport and Norfolk areas.

Environmental Component	Section of DEIS Analyzing Potential Impacts	Description of Potential Impact	Comparison of Alternative Areas
IMPACTS EVALUATED UNDER NEPA [a] (impacts onshore and within U.S. territorial seas)			
Physical Environment	4.1.1	No significant direct or indirect impacts on geology and sediments, air quality and noise, or water quality.	Mayport and Norfolk similar.
Biological Environment	4.1.2	No significant direct or indirect impacts on marine biota, including plankton, pelagic fish, marine mammals, sea turtles, benthic organisms, and seabirds.	Mayport and Norfolk similar.
Socioeconomic Environment	4.1.3	No significant direct or indirect impacts on the local economy, including ship traffic and the fishing and tourism industries.	Mayport and Norfolk similar.
IMPACTS EVALUATED UNDER EXECUTIVE ORDER 12114 (impacts outside U.S. territorial seas)			
Physical Environment			
Geology and sediments	4.2.1.1	Metal fragments will be deposited on the seafloor. No cratering or sediment disturbance expected.	Mayport and Norfolk similar.
Air quality	4.2.1.2	Temporary, localized increase in concentrations of explosion products in the atmosphere. No hazard to marine or human life.	Mayport and Norfolk similar.
Water quality	4.2.1.3	Temporary, localized increase in concentrations of explosion products in the ocean. No hazard to marine life.	Mayport and Norfolk similar.

Table 2-5. (Continued).

Environmental Component	Section of DEIS Analyzing Potential Impacts	Description of Potential Impact	Comparison of Alternative Areas
Biological Environment			
Plankton	4.2.2.1	Plankton near the detonation point would be killed, but populations would be rapidly replenished through reproduction and mixing with adjacent waters.	Mayport and Norfolk similar.
Fish	4.2.2.2	Pelagic (water column) fish near the detonation point may be killed or injured. Many of the same species occur at both areas. Demersal (bottom) fish will not be affected.	Mayport and Norfolk similar.
Marine mammals	4.2.2.3	Mitigation will minimize risk, but marine mammals could be killed or injured if not detected within the safety range. At greater distances, animals may experience brief acoustic discomfort, with no lasting effects expected.	Much less risk of impacts at Mayport because marine mammal densities are much lower there.
Sea turtles	4.2.2.4	Mitigation will minimize risk, but turtles could be killed or injured if not detected within the safety range. At greater distances, turtles may experience brief acoustic discomfort, with no lasting effects expected.	Mayport and Norfolk similar. Testing would not occur at Mayport during April when turtle densities are higher.
Benthos	4.2.2.5	No direct effect on benthic organisms is expected. No habitat disturbance is expected. Metal fragments deposited on the seafloor will be colonized by invertebrates and attract fish.	Mayport and Norfolk similar.

Table 2-5. (Continued).

Environmental Component	Section of DEIS Analyzing Potential Impacts	Description of Potential Impact	Comparison of Alternative Areas
Seabirds	4.2.2.6	Seabirds above the detonation point could be killed or stunned by the plume of water ejected into the air. Other seabirds resting or feeding at the surface could be killed or injured by the shock wave. It is unlikely that more than a few birds would be affected.	Mayport and Norfolk similar.
Socioeconomic Environment			
Commercial and recreational fisheries	4.2.3.1	Individuals of commercial or recreational fishery species may be killed or injured, but no significant impact on fishery stocks is expected. Commercial and recreational fishing activities within 18.5 km (10 nmi) of the detonation point will be temporarily interrupted.	Mayport and Norfolk similar.
Ship traffic	4.2.3.2	Ship traffic passing within 18.5 km (10 nmi) of the detonation point would need to alter course or be escorted from the area.	Mayport and Norfolk similar.

[a] Shore support operations and movement of vessels and aircraft within territorial seas are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases.

Table 2-6. Comparison of Mayport and Norfolk areas with respect to potential impacts on marine mammals and turtles.

Criterion	Alternative Area	
	Mayport	Norfolk
Marine Mammals		
• Potential mortality (with mitigation), total number of animals from five detonations[a]	1	8
• Potential injury (with mitigation), total number of animals from five detonations[a]	5	38
• Potential acoustic discomfort (with mitigation), total number of animals from five detonations[a]	570	4,819
• Mitigation effectiveness (percent of total marine mammals present during a single shock test likely to be detected by aerial and surface observers)[b]	93%	93%
Sea Turtles		
• Potential mortality (with mitigation), total number of animals from five detonations[c]	6	7
• Potential injury (with mitigation), total number of animals from five detonations[c]	30	32
• Potential acoustic discomfort (with mitigation), total number of animals from five detonations[c]	293	311
• Mitigation effectiveness (percent of total sea turtles present during a single shock test likely to be detected by aerial and surface observers)[d]	8%	8%

[a] From Table 4-6. Expected number of marine mammals within maximum ranges for mortality, injury, or acoustic discomfort, taking into account mitigation effectiveness for each species.
[b] From Table 4-6. Mitigation effectiveness for mortality and injury.
[c] From Table 4-9. Expected number of sea turtles within maximum ranges for mortality, injury, or acoustic discomfort, taking into account mitigation effectiveness for each species.
[d] From Table 4-9. Mitigation effectiveness for mortality and injury.

2.4 PREFERRED ALTERNATIVE

Based on the preceding discussion, the preferred alternative is to shock test the SEAWOLF submarine offshore of Mayport, Florida, between 1 May and 30 September with mitigation to minimize risk to marine mammals and turtles. This alternative meets the project purpose and need, satisfies operational criteria, and minimizes environmental impacts. The Norfolk area also meets the project purpose and need and satisfies operational criteria; however, the higher density of marine mammals in the area could increase the risk of impacts.

3.0 EXISTING ENVIRONMENT

This section describes a baseline of the physical, biological, and socioeconomic environment of the Mayport and Norfolk areas. It focuses on topics that are most relevant to evaluating potential impacts of the proposed action. Additional information for the Mayport area is provided in the environmental documentation prepared by the Department of the Navy (1995a).

The environment is similar at the Mayport and Norfolk areas because both are located along the east coast at the same water depth and about the same distance from shore. To avoid redundancy, separate sections for Mayport and Norfolk are not presented. Instead, the environment at the two areas is contrasted within each major subsection.

3.1 PHYSICAL ENVIRONMENT

3.1.1 Geology and Sediments

Mayport

The Mayport area lies near the shelf break, a region of relatively steep slope which separates the continental shelf from the Florida-Hatteras continental slope. The continental shelf, which extends out to the 200 m (656 ft) depth contour, is about 117 km (63 nmi) wide offshore of Mayport. The Florida-Hatteras continental slope extends seaward of the area down to depths of about 2,000 m (6,560 ft). The shelf break region where the area is located has a bottom slope of about 3%.

Sediments at the Mayport area are mainly sand (Department of the Interior [DOI], Minerals Management Service [MMS], 1983a). Small areas have mainly silty sand, and sediments along the southern portion of the area are a mixture of sand, silt, and clay. There are no known hard bottom areas or reefs within 1.85 km (1 nmi) of the Mayport area (Department of the Navy, 1995a).

Norfolk

The Norfolk area lies just inshore of the continental shelf/slope break, which is at a depth of about 200 m (656 ft). The continental shelf is about 120 km (65 nmi) wide east of Norfolk. The continental slope is seaward of the shelf edge and extends down to depths of about 2,000 m (6,560 ft). The shelf break region where the area is located is steeper than the Mayport area, with bottom slope ranging from about 3% to 8%.

Sediments overlying the southern portion of the Norfolk area are primarily sand. Areas of sand, silt, and clay occur offshore of the central and northern portions of the Norfolk area (DOI, MMS, 1983b). There are no known hard bottom areas or reefs within 1.85 km (1 nmi) of the Norfolk area (Department of the Navy, 1995a).

3.1.2 Physical Oceanography and Meteorology

The Gulf Stream is a major influence on the physical oceanography of both the Mayport and Norfolk areas. Though the continental shelf is broad at both areas, the Gulf Stream flows northward, directly against the continental shelf and over the slope, at the Mayport area, but veers easterly and flows some distance away from the continental shelf at the Norfolk area. The northeasterly turn of the Gulf Stream occurs at a feature called the Charleston Bump, located northeast of the Mayport area (**Figure 3-1**). Cape Hatteras is an important point along the path of the Gulf Stream, as this is where it begins its more easterly turn into the North Atlantic and is no longer constrained by the continental shelf and slope. Between the Charleston Bump and Cape Hatteras, the Gulf Stream exhibits features such as rings, meanders, and filaments which can affect shelf waters (Texas Instruments, Inc., 1979; Science Applications International Corporation, 1984; Florida Institute of Oceanography, 1986).

Mayport

Currents and water masses at the Mayport area are mainly influenced by the Gulf Stream's deflections, meanders, and flow. Off northeastern Florida, the Gulf Stream flows consistently northward. Mean current speeds at the Mayport area range from 180 cm/sec (3.5 kt) near the surface to 40 cm/sec (0.8 kt) near the bottom (Lee and Waddell, 1983). Additional current speed measurements from the region range from 30 cm/sec (0.6 kt) in December to 50 cm/sec (1.0 kt) in July (Department of the Navy, 1989).

The two main water masses at the Mayport area are shelf water and the Gulf Stream. The average position of the Gulf Stream's western wall is over or just inshore of the area throughout the year. Although the Gulf Stream's position remains fairly stable in this region, lateral meandering does occur (Bane et al., 1981; Lee et al., 1981; Department of the Navy, 1995a). Depending on their phase, meanders can cause the Gulf Stream to be shoreward or well seaward of the area. Frontal eddies, filaments, warm core rings, and cold core rings may form during development of a meander and move across the Mayport area and onto the shelf.

Wave heights offshore northeastern Florida vary seasonally and average 1.2 m (3.9 ft). Waves are smallest from April through September (0.8 to 1.2 m, or 2.6 to 3.9 ft) and largest from October to March (1.3 to 1.6 m, or 4.3 to 5.2 ft). Waves greater than 1 m (3.3 ft) occur most frequently during winter and least frequently during summer (Department of the Navy, 1989).

Shipboard observations indicate that the Mayport area has good visibility ($\geq$18.5 km or 10 nmi) most of the time during the April through September period (Department of the Navy, 1989). The area also has a low incidence of fog during these months. Data are presented in Section 2.2.2.1.

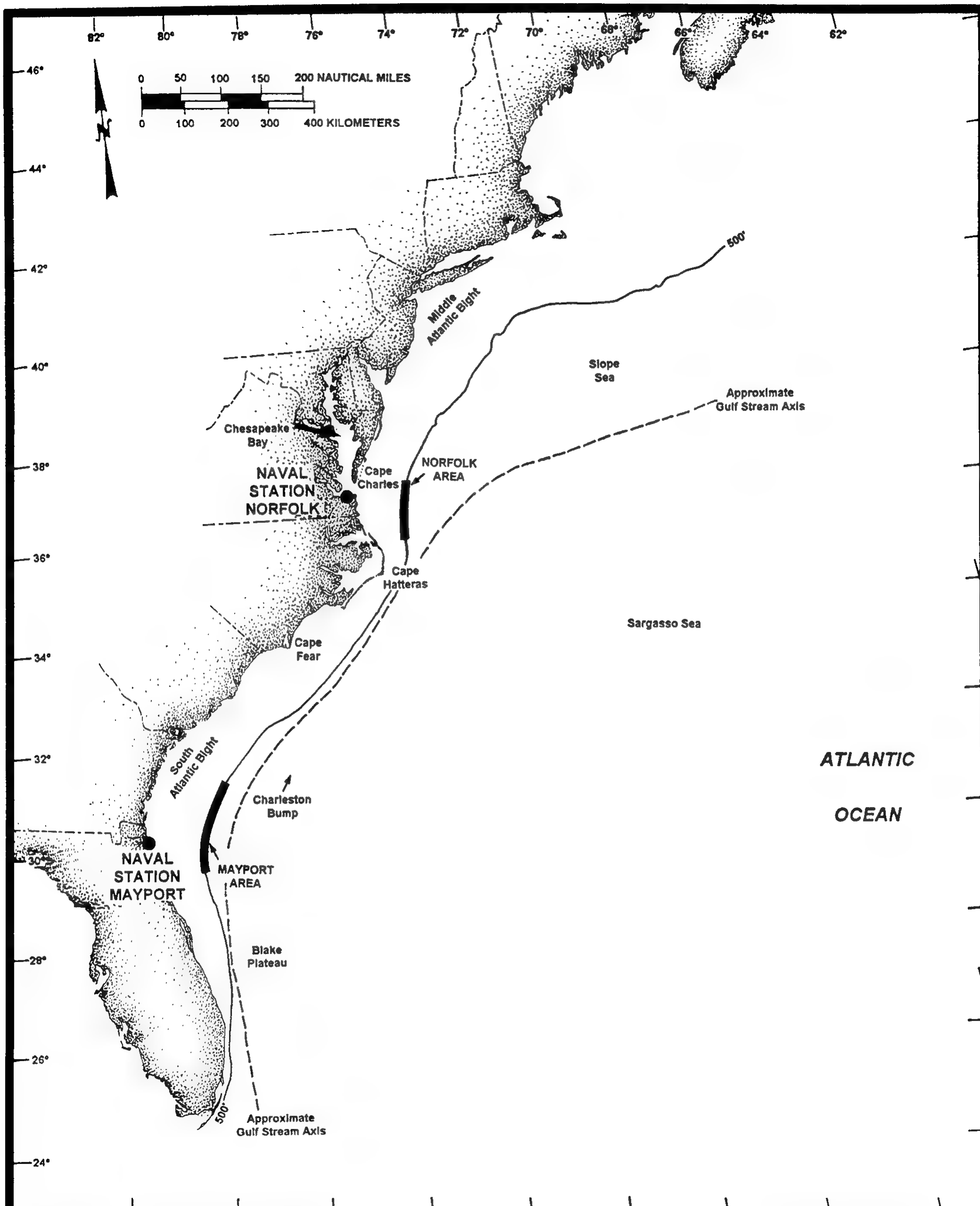


Figure 3-1. Regional oceanographic features of the Atlantic coast and the approximate Gulf Stream axis (Adapted from: Science Applications International Corporation, 1993).

Norfolk

The Gulf Stream flows east away from the shelf/slope boundary at the Norfolk area, and the position of its western wall changes seasonally (Department of the Navy, 1995a). During spring, the average position of the western wall is more than 37 km (20 nmi) east of the area. During fall, the Gulf Stream meanders northward and over the area (Marine Geosciences Applications, Inc., 1984). The circulation regime in the area is dynamic due to a confluence of several water masses including the Slope Sea Gyre, shelf water, and Gulf Stream. Frontal eddies, filaments, warm core rings, and cold core rings form as the result of Gulf Stream meandering along the shelf and slope.

Current speeds at the Norfolk area vary seasonally and are greatly influenced by Gulf Stream meanders. Current speeds average 30 cm/sec (0.6 kt). When the Gulf Stream is displaced in winter (October to January), surface currents range from about 20 to 50 cm/sec (0.4 to 1.0 kt) to the south (Science Applications International Corporation, 1987). When the Gulf Stream returns to its original position, this southerly flow decreases.

Annual mean wave height observed on board ships and reported by the National Climatic Data Center (1992) was 1.2 m (3.9 ft). Wave heights were lowest from April through September (0.9 to 1 m, or 2.9 to 3.3 ft) and highest from October to March (1.1 to 1.5 m, or 3.6 to 4.9 ft). The percent frequency of waves higher than 1 m (3.3 ft) at the Norfolk area ranges from 60% to 90% in winter months (Department of the Navy, 1989).

Shipboard observations indicate the Norfolk area has good visibility (≥18.5 km or 10 nmi) most of the time during the April through September period (Department of the Navy, 1989). The area has a low incidence of fog during these months. Data are presented in Section 2.2.2.1.

3.1.3 Water Quality

Water quality at the Mayport and Norfolk areas has been described by the Department of the Navy (1995a). Because both areas are well offshore, water quality is excellent, with high water clarity, low concentrations of suspended matter, dissolved oxygen concentrations at or near saturation, and low concentrations of contaminants such as trace metals and hydrocarbons.

3.2 BIOLOGICAL ENVIRONMENT

This section describes the potentially affected biological environment of the Mayport and Norfolk areas. Hard bottom habitats, both natural and artificial, are not discussed because none are present within 1.85 km (1 nmi) of either area (see Section 2.2.2.2).

3.2.1 Plankton

Information on phytoplankton, primary productivity, zooplankton, ichthyoplankton, neuston, and *Sargassum* communities at the Mayport and Norfolk areas has been summarized by the Department of the Navy (1995a). A discussion of

ichthyoplankton is included here due to the importance of commercial and recreational fisheries in the region. *Sargassum* communities are also described as they are an important habitat for small fish and juvenile sea turtles.

3.2.1.1 Ichthyoplankton

Most fish inhabiting the Atlantic Ocean have eggs and larvae which become part of the planktonic community for about 10 to 100 days (depending on the species). Variability in survival and transport of ichthyoplankton (fish eggs and larvae) is thought to be an important factor affecting the size of adult fish populations (Underwood and Fairweather, 1989; Doherty and Fowler, 1994).

According to Miller (1989), very few fish eggs and larvae are found in the Gulf Stream. Thus, abundances of ichthyoplankton at either the Mayport or Norfolk area could be expected to vary substantially depending on the position of the Gulf Stream and its filaments and meanders.

Mayport

Fish eggs and larvae found in the South Atlantic Bight are mainly from warm temperate and tropical regions (Powles and Stender, 1976). The warm temperate species are spawned within the Bight, whereas the tropical eggs and larvae are carried into the area from more southerly spawning locations. Several of the region's commercially important species including Atlantic menhaden, Atlantic croaker, spot, summer flounder, and southern flounder migrate from nearshore shelf waters to the shelf edge to spawn (Miller et al., 1984). The larvae of these species are transported back across the shelf and eventually into inshore/estuarine nursery areas.

Within the South Atlantic Bight, fish eggs and larvae are generally distributed in an onshore/offshore pattern (Powles and Stender, 1976). Depending on the position of the Gulf Stream front, the ichthyoplankton at the Mayport area is likely to be a mixture of slope and shelf/slope groups. The slope group is typified by lanternfish throughout the year. During spring, mackerel larvae reach peak abundance. Members of the slope group at other times of the year include inshore species such as gobies, wrasses, and flounders. The shelf/slope group includes fish such as lefteye flounders, jacks, mullets, bluefish, filefish, goatfish, and sea basses; several of these are economically important species. The composition and abundance of ichthyoplankton at any particular time will depend upon the position of the Gulf Stream front (Govoni, 1993).

Norfolk

Fish eggs and larvae found in the Mid-Atlantic Bight come from warm temperate, cold temperate, and boreal regions (Doyle et al., 1993). In general, the most abundant fish eggs and larvae found during winter months are those of cold temperate species originating in more northerly waters. During spring, summer, and fall months the ichthyoplankton is dominated by warm temperate species originating from more southerly waters.

Within the Mid-Atlantic Bight, fish eggs and larvae are generally distributed in an onshore/offshore pattern including inner shelf, outer shelf, and slope/oceanic groups

(Doyle et al., 1993). Factors such as temperature, salinity, frontal boundary positions, and locations of adult spawning sites contribute to the formation and maintenance of these groups (Grosslein and Azarovitz, 1982; Cowen et al., 1993). Depending on the position of the Gulf Stream front, the outer shelf and slope/oceanic groups would be the most likely to occur at the Norfolk area. The lanternfish *Benthosema glaciale* and *Ceratoscopelus maderensis* define the slope/oceanic group (Doyle et al., 1993). *Benthosema glaciale* reaches peak abundance in winter and spring, whereas *C. maderensis* is most abundant in spring, summer, and fall. The slope/oceanic group also includes shelf species whose distribution extends somewhat into the slope/oceanic areas. In spring, Atlantic mackerel larvae are abundant, and in summer silver hake and some flatfish larvae occur with *C. maderensis*. The outer shelf group includes witch flounder, silver hake, Atlantic bonito, cusk-eels, and species from more southerly waters such as razorfish, lefteye flounders, and gobies (Hare and Cowen, 1991; Cowen et al., 1993; Doyle et al., 1993).

3.2.1.2 Sargassum Communities

An important component of the planktonic community is the floating brown alga *Sargassum*, a seaweed that permanently drifts at the surface in warm waters (Fine, 1970). The Gulf Stream provides a fairly constant input of drifting weed and its associated fauna to the Atlantic community. It has been estimated that *Sargassum* covers nearly two million square miles at a density of two to five tons per square mile (Dooley, 1972).

Sargassum normally occurs in scattered individual clumps ranging in size from 10 to 50 cm (4 to 20 in.) in diameter. Clumps may be spaced several hundred meters apart (Butler et al., 1983). Accumulation of *Sargassum* and other flotsam in lines is often an indicator of a convergence zone between water masses. Convergence zones are sites of considerable biological activity, and many species including juvenile sea turtles and pelagic fish will gather along these zones whether *Sargassum* or other flotsam is present or not (Carr, 1986). Fishermen also use flotsam as visual cues to find convergence zones.

Over 100 different species have been identified as associated with floating *Sargassum* (Morris and Mogelberg, 1973), although the number of routine resident species within a typical *Sargassum* community is considerably lower (Butler et al., 1983). *Sargassum* is also important as cover for many temporary associates such as juvenile fish and sea turtles. Some of the temporary associates are seasonal residents, whereas others are intermittent residents or accidental strays (Butler et al., 1983).

As many as 54 fish species are closely associated with floating *Sargassum* at some point in their life cycle, but only two spend their entire lives there: the sargassumfish and the sargassum pipefish (Adams, 1960; Dooley, 1972; Bortone et al., 1977). Most fish associated with *Sargassum* are temporary residents, such as juveniles of species which reside in shelf or coastal waters as adults (McKenney et al., 1958; Berry, 1959; Parin, 1970; Dooley, 1972; Bortone et al., 1977). However, several larger species of recreational or commercial importance including dolphinfish, yellowfin tuna, blackfin tuna, skipjack tuna, Atlantic bonito, little tunny, and wahoo feed on the small fish and invertebrates attracted to *Sargassum* (Morgan et al., 1985).

Sargassum communities at the Mayport and Norfolk areas should be generally similar. However, *Sargassum* communities off Virginia are less diverse than those off the Florida coast (Stoner and Greening, 1984).

3.2.2 Pelagic Fish

Pelagic (water column) fish are often grouped by their water mass preference. Those species preferring shelf waters are classified as coastal pelagic, and those species preferring oceanic waters (particularly the western edge of the Gulf Stream) are classified as oceanic pelagic. Both areas have a mixture of oceanic and coastal pelagic fish. Additional information on commercially and recreationally important fishery species is provided in Section 3.3.1.

Mayport

Because the Mayport area is dominated by the Gulf Stream, fish found there are primarily oceanic pelagic. This group includes highly migratory species such as dolphinfish, blue marlin, white marlin, sailfish, swordfish, tunas, and wahoo. In general, oceanic pelagic species associate with the western edge of the Gulf Stream and travel near this edge as they migrate through the area. Flotsam accumulates along the Gulf Stream/shelf water interface where downwelling occurs (Carr, 1986). Dolphinfish, tunas, and wahoo feed on small fish and invertebrates associated with drifting *Sargassum* and other flotsam (e.g., Manooch et al., 1983; Manooch and Mason, 1984; Morgan et al., 1985). The flotsam/*Sargassum* community has been described above under Plankton.

Although coastal pelagic fish normally occur inshore of the area, some species may occasionally occur near the Mayport area during migratory movements or extreme lateral (eastward) deflections of the Gulf Stream. Spanish mackerel, king mackerel, little tunny, jacks, requiem sharks, and cobia represent the larger predatory members of the coastal pelagic group found in this area. Smaller coastal pelagic fish include Atlantic menhaden, round scad, dwarf herring, butterfish, and chub mackerel. Wenner et al. (1980) collected dwarf herring, round scad, and butterfish in trawl samples taken just north of the Mayport area offshore of Savannah, Georgia between a water depth of 110 to 183 m (361 to 600 ft).

Norfolk

Highly migratory forms such as yellowfin tuna, bigeye tuna, bluefin tuna, white marlin, spearfish, blue marlin, sailfish, swordfish, wahoo, and dolphinfish comprise the oceanic pelagic species group at the Norfolk area. All life stages (eggs, larvae, juveniles, adults) of these species are closely associated with the Gulf Stream and could occur in the area. Some species, particularly dolphinfish, tunas, and wahoo feed upon small fish attracted to *Sargassum* and other flotsam (Manooch et al., 1983; Manooch and Mason, 1984; Morgan et al., 1985). Oceanic pelagic fish are present year round in the area, with billfish, dolphinfish, and tunas reaching peak abundances during spring, summer, and fall months.

Grosslein and Azarovitz (1982) reported that sharks were the most well represented group of coastal pelagic fish in the vicinity of the Norfolk area. Although primarily migrants or strays from outside their principal range, 47 shark species were

reported from the coastal and oceanic waters near the Norfolk area (Grosslein and Azarovitz, 1982). About a dozen of the shark species caught were large, and all were seasonal migrants. Most of these sharks did not normally occur in large numbers. Among the five most commonly encountered species in the depth of the Norfolk area, the sandbar shark is generally restricted to shelf waters. Other commonly encountered sharks were the blue shark, dusky shark, mako sharks, and hammerheads. Although occasionally found in relatively shallow water, these sharks usually frequent deep ocean waters and are considered oceanic pelagic.

A small number of bony, coastal pelagic fish were reported from the approximate depth of the Norfolk area (Grosslein and Azarovitz, 1982). As with the sharks, most of these species were migrants, and not found in the area during the entire year. The predominant species were the Atlantic mackerel, bluefish, Atlantic menhaden, alewife, and butterfish. Holland and Keefe (1977) also reported bycatch of chub mackerel during trawling out to 380 m (1,247 ft) off Virginia. Other coastal pelagic species potentially occurring near the Norfolk area include little tunny, king mackerel, Spanish mackerel, and cobia. These species are usually more abundant inshore, but could venture into the area.

3.2.3 Marine Mammals

Marine mammals potentially occurring at the Mayport and Norfolk areas are listed in **Table 3-1**. The table summarizes the status and historical presence of each species and provides density estimates based on 1995 aerial surveys. Species descriptions are provided in Appendix B.

To supplement historical information, monthly aerial surveys were conducted at the Mayport and Norfolk areas from April through September 1995 (Department of the Navy, 1995b). Methods are summarized in Appendix B. Parallel survey transects were 1.85 km (1 nmi) apart, with each transect extending 7.4 km (4 nmi) to the east and west of the 152 m (500 ft) depth contour at each area. Standard methods were used, as developed by the NMFS (Blaylock, 1994; Hoggard, 1994; Mullin, 1994). Observers on both sides of the aircraft scanned a swath of sea surface for marine mammals. The total area viewed during each survey was 2,948 km^2 (858 nmi^2) at the Mayport area and 1,470 km^2 (428 nmi^2) at the Norfolk area.

Observed densities from aerial surveys do not take into account submerged individuals or those that may have been on the surface but undetected. Therefore, adjusted densities were developed for each species as explained in Appendix B. **Figure 3-2** shows observed and adjusted densities of marine mammals at Mayport and Norfolk based on the 1995 aerial surveys.

Mayport

Based on historical records and aerial survey results, 29 marine mammal species may occur at the Mayport area, including 7 baleen whales and 22 toothed whales and dolphins (**Table 3-1**). Six of these are considered likely to occur (presence probable): Atlantic spotted dolphin, bottlenose dolphin, pantropical spotted dolphin,

Table 3-1. Status, historical presence, and densities of marine mammals potentially occurring at the Mayport and Norfolk areas.

Common and Scientific Name	Status[a]	Historical Presence[b]		Observed Mean Density From 1995 Aerial Surveys)[c] (Individuals/100 km^2)			Adjusted Mean Density[d] (Individuals/100 km^2)		
		Mayport	Norfolk	Mayport	Mayport (excluding April)	Norfolk	Mayport	Mayport (excluding April)	Norfolk
BALEEN WHALES (Mysticetes)									
Fin whale (*Balaenoptera physalus*)	E	+	++	0	0	0.52	0	0	2.90
Humpback whale (*Megaptera novaeangliae*)	E	+	++	0	0	0.01	0	0	0.06
Minke whale (*Balaenoptera acutorostrata*)	--	+	++	0	0	0.02	0	0	0.25
Sei whale (*Balaenoptera borealis*)	E	+	++	0	0	0.02	0	0	0.13
Sei/Bryde's whale (*Balaenoptera borealis/edeni*)	E/--	+	++/+	0	0	0.01	0	0	0.06
Unidentified *Balaenoptera* sp.	NA	NA	NA	0	0	0.14	0	0	0.76
Unidentified large baleen whale	NA	NA	NA	0	0	0.05	0	0	0.25
Blue whale (*Balaenoptera musculus*)	E	+	+	0	0	0	0	0	0
Bryde's whale (*Balaenoptera edeni*)	--	+	+	0	0	0	0	0	0
Northern right whale (*Eubalaena glacialis*)	E	+	+	0	0	0	0	0	0
TOOTHED WHALES AND DOLPHINS (Odontocetes)									
Atlantic spotted dolphin (*Stenella frontalis*)	--	++	++	0.88	0.52	9.34	4.90	2.90	51.90
Bottlenose dolphin (*Tursiops truncatus*)	PT	++	++	1.39	0.53	5.83	7.70	2.94	32.38
Bottlenose/Atlantic spotted dolphin (*Tursiops truncatus/Stenella frontalis*)	PT/--	++	++	0.15	0.18	0.73	0.82	0.98	4.03
Clymene/spinner/striped dolphin (*Stenella clymene/longirostris/coeruleoalba*)	--	+/++	+/++	0.25	0.13	2.78	1.38	0.72	15.43
Common dolphin (*Delphinus delphis*)	--	+	++	0	0	3.51	0	0	19.53
Cuvier's beaked whale (*Ziphius cavirostris*)	--	+	+	0	0	0.02	0	0	0.25

Table 3-1. (Continued).

Common and Scientific Name	Status[a]	Historical Presence[b]		Observed Mean Density From 1995 Aerial Surveys)[c] (Individuals/100 km^2)			Adjusted Mean Density[d] (Individuals/100 km^2)		
		Mayport	Norfolk	Mayport	Mayport (excluding April)	Norfolk	Mayport	Mayport (excluding April)	Norfolk
Pantropical spotted dolphin (*Stenella attenuata*)	--	++	++	2.19	1.55	4.93	12.15	8.63	27.40
Pilot whale (*Globicephala* spp.)[e]	--	++	++	0	0	15.60	0	0	86.67
Risso's dolphin (*Grampus griseus*)	--	++	++	1.10	1.19	1.35	6.12	6.60	7.50
Sperm whale (*Physeter macrocephalus*)	E	+	+	0.01	0.01	0.05	0.13	0.15	0.50
Spinner dolphin (*Stenella longirostris*)	--	++	++	0.28	0.34	0.70	1.57	1.88	3.91
Striped dolphin (*Stenella coeruleoalba*)	--	+	+	0	0	0.27	0	0	1.51
Unidentified dolphin	NA	NA	NA	1.12	1.28	4.38	6.22	7.09	24.31
Unidentified small whale	NA	NA	NA	0	0	0.06	0	0	0.32
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	--	--	+	0	0	0	0	0	0
Blainville's beaked whale (*Mesoplodon densirostris*)	--	+	+	0	0	0	0	0	0
Clymene dolphin (*Stenella clymene*)	--	+	+	0	0	0	0	0	0
Dwarf sperm whale (*Kogia simus*)	--	+	+	0	0	0	0	0	0
False killer whale (*Pseudorca crassidens*)	--	+	+	0	0	0	0	0	0
Fraser's dolphin (*Lagenodelphis hosei*)	--	+	+	0	0	0	0	0	0
Gervais' beaked whale (*Mesoplodon europaeus*)	--	+	+	0	0	0	0	0	0
Harbor porpoise (*Phocoena phocoena*)	PT	--	+	0	0	0	0	0	0
Killer whale (*Orcinus orca*)	--	+	+	0	0	0	0	0	0
Melon-headed whale (*Peponocephala electra*)	--	+	+	0	0	0	0	0	0
Northern bottlenose whale (*Hyperoodon ampullatus*)	--	--	+	0	0	0	0	0	0

Table 3-1. (Continued).

Common and Scientific Name	Status[a]	Historical Presence[b]		Observed Mean Density From 1995 Aerial Surveys)[c] (Individuals/100 km^2)			Adjusted Mean Density[d] (Individuals/100 km^2)		
		Mayport	Norfolk	Mayport	Mayport (excluding April)	Norfolk	Mayport	Mayport (excluding April)	Norfolk
Pygmy killer whale (*Feresa attenuata*)	--	+	+	0	0	0	0	0	0
Pygmy sperm whale (*Kogia breviceps*)	--	+	+	0	0	0	0	0	0
Rough-toothed dolphin (*Steno bredanensis*)	--	+	+	0	0	0	0	0	0
Sowerby's beaked whale (*Mesoplodon bidens*)	--	--	+	0	0	0	0	0	0
True's beaked whale (*Mesoplodon mirus*)	--	+	+	0	0	0	0	0	0
SEALS (Pinnipeds)									
Harbor seal (*Phoca vitulina*)	--	--	+	0	0	0	0	0	0
TOTAL MARINE MAMMALS (rounded to nearest whole number)				**7** (7.37)	**6** (5.73)	**50** (50.32)	**41** (40.99)	**32** (31.89)	**280** (280.05)

NA = not applicable.

[a] Status: E = endangered species, PT = proposed for listing as a threatened species. The PT designation for the bottlenose dolphin applies only to the coastal population, which is not likely to occur at either offshore area.

[b] Historical Presence: ++ = presence probable based on historical sightings data; + = presence possible based on historical sightings data, but a depth or latitudinal limit may exist. Sources: Leatherwood et al., 1976; CETAP, 1982; Duffield et al., 1983; Payne et al., 1984; Lee, 1985a; Duffield, 1986; Kenney et al., 1986; Winn et al., 1986; Kenney and Winn, 1987; Kraus et al., 1988, 1993; Knowlton and Kraus, 1989; Manomet Bird Observatory, 1989; Hersh and Duffield, 1990; Kenney, 1990; Mayo and Marx, 1990; DOI, MMS, 1990; Kraus and Kenney, 1991; Mitchell, 1991; NMFS, 1991a,b; Payne and Heinemann, 1993; Schaeff et al., 1993; Blaylock and Hoggard, 1994.

[c] Observed mean densities are from six aerial surveys conducted during April-September 1995 (Department of the Navy, 1995c). Mean densities (individuals/100 km^2) are based on total number of individuals sighted ÷ area surveyed (2,948 km^2 for Mayport or 1,470 km^2 for Norfolk) ÷ 6 surveys × 100. Because there would be no testing in April in Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April).

[d] Adjusted densities take into account estimated numbers of submerged individuals and those that may have been undetected on the surface. Appendix B explains how adjusted densities were calculated for each species. Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data.

[e] The two species of pilot whales in the western Atlantic, the long-finned pilot whale (*Globicephala melaena*) and short-finned pilot whale (*G. macrorhynchus*), are difficult to differentiate in the field and have been combined in this analysis.

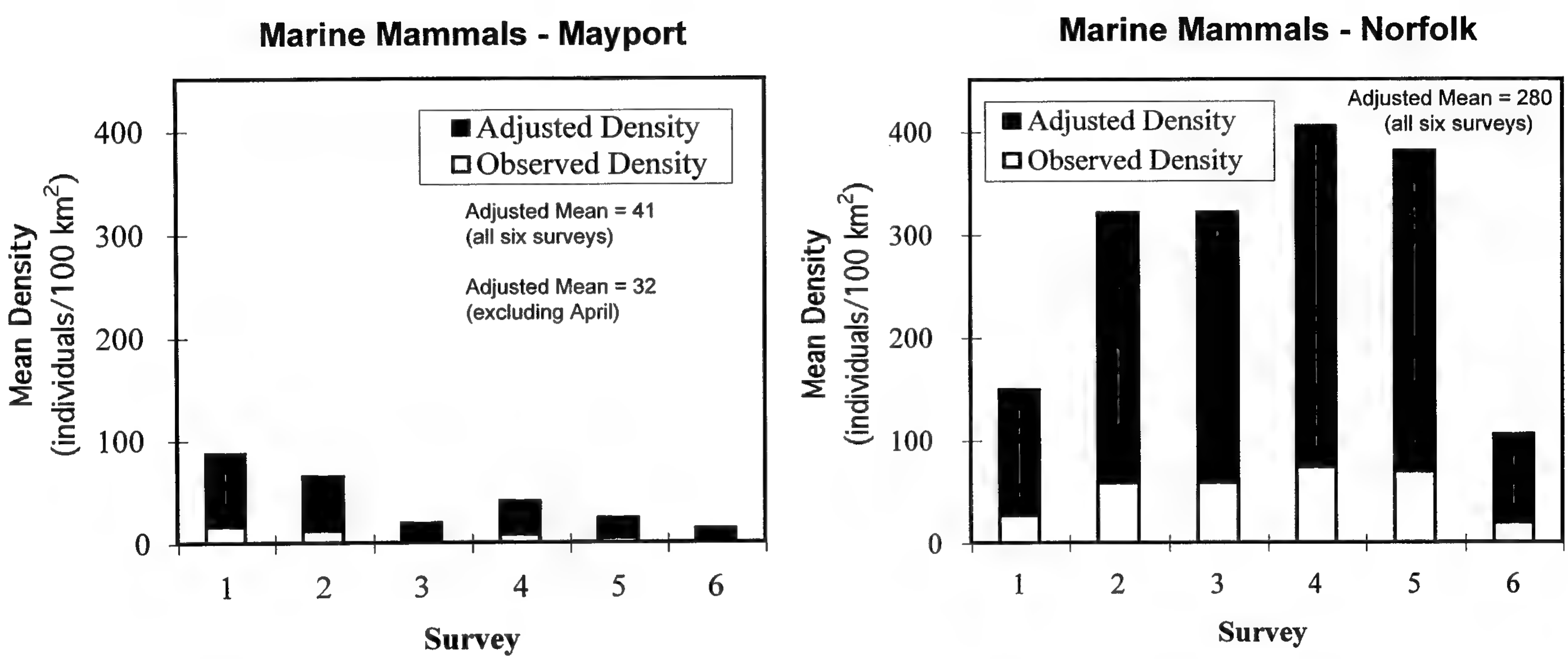


Figure 3-2. Marine mammal densities at the Mayport and Norfolk areas, based on six aerial surveys conducted during April through September 1995 (Data from: Department of the Navy, 1995b). Observed densities were adjusted to account for submerged and undetected individuals as explained in Appendix B.

Risso's dolphin, spinner dolphin, and pilot whale. The other 23 species could occur in the area but are not especially likely to be found there (presence possible).

A total of 1,303 individuals representing at least seven species of marine mammals were seen at the Mayport area during the 1995 aerial surveys. Based on all six surveys, observed mean densities of marine mammals were about 7 individuals/100 km^2, and adjusted mean densities were about 41 individuals/100 km^2. Because there would be no shock testing in April at Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April). For the May-September period, observed mean densities were about 6 individuals/100 km^2 and adjusted mean densities were about 32 individuals/100 km^2. The most abundant species were pantropical spotted dolphin, bottlenose dolphin, Risso's dolphin, Atlantic spotted dolphin, and spinner dolphin.

Total marine mammal densities at the Mayport area were relatively low on all surveys (in comparison to the Norfolk area) (**Figure 3-2**). Densities at Mayport were highest on the first two surveys, when the most abundant species were pantropical spotted dolphin (April and May), bottlenose dolphin (April), and Risso's dolphin (May).

Figure 3-3 shows the abundance of marine mammals along individual transects at the Mayport area. Numbers of marine mammals on a transect ranged from 0 to 80 individuals; within any given survey, most transects had zero. Marine mammal abundance and frequency of occurrence was greatest during April and lowest during September. Marine mammals were generally more abundant and widespread in the southern half of the area.

Six of the marine mammals potentially occurring at Mayport are listed as endangered as defined by the Endangered Species Act of 1973. These are the blue whale, fin whale, humpback whale, northern right whale, sei whale, and sperm whale. However, none are listed as "presence probable," and the only endangered species seen during 1995 aerial surveys was the sperm whale (two individuals were sighted). Because blue, fin, humpback, and northern right whales generally inhabit northern feeding grounds during spring, summer, and early fall, it is not surprising that none were seen near Mayport during the April through September surveys. Critical habitat for the northern right whale is located off northeastern Florida but is well inshore of the Mayport area (see Appendix B).

Of 23 species with historical distributional records indicating "presence possible" at Mayport, 22 were not seen during the 1995 aerial surveys. This includes all 7 species of baleen whales and 15 species of toothed whales and dolphins. Species such as dwarf and pygmy sperm whales (*Kogia* spp.) and pilot whales (*Globicephala* spp.) were not seen, although they occur frequently in stranding reports from the southeastern U.S. (Tyack, 1996). As noted above for several baleen whales, some of these absences can be explained by seasonality (i.e., many species tend to inhabit northern feeding grounds during spring, summer, and early fall). Other factors possibly explaining species absence include low abundance, depth and/or habitat preferences outside of the area, year-to-year variability, and behavioral traits such as aircraft avoidance and short surface times in deep diving species.

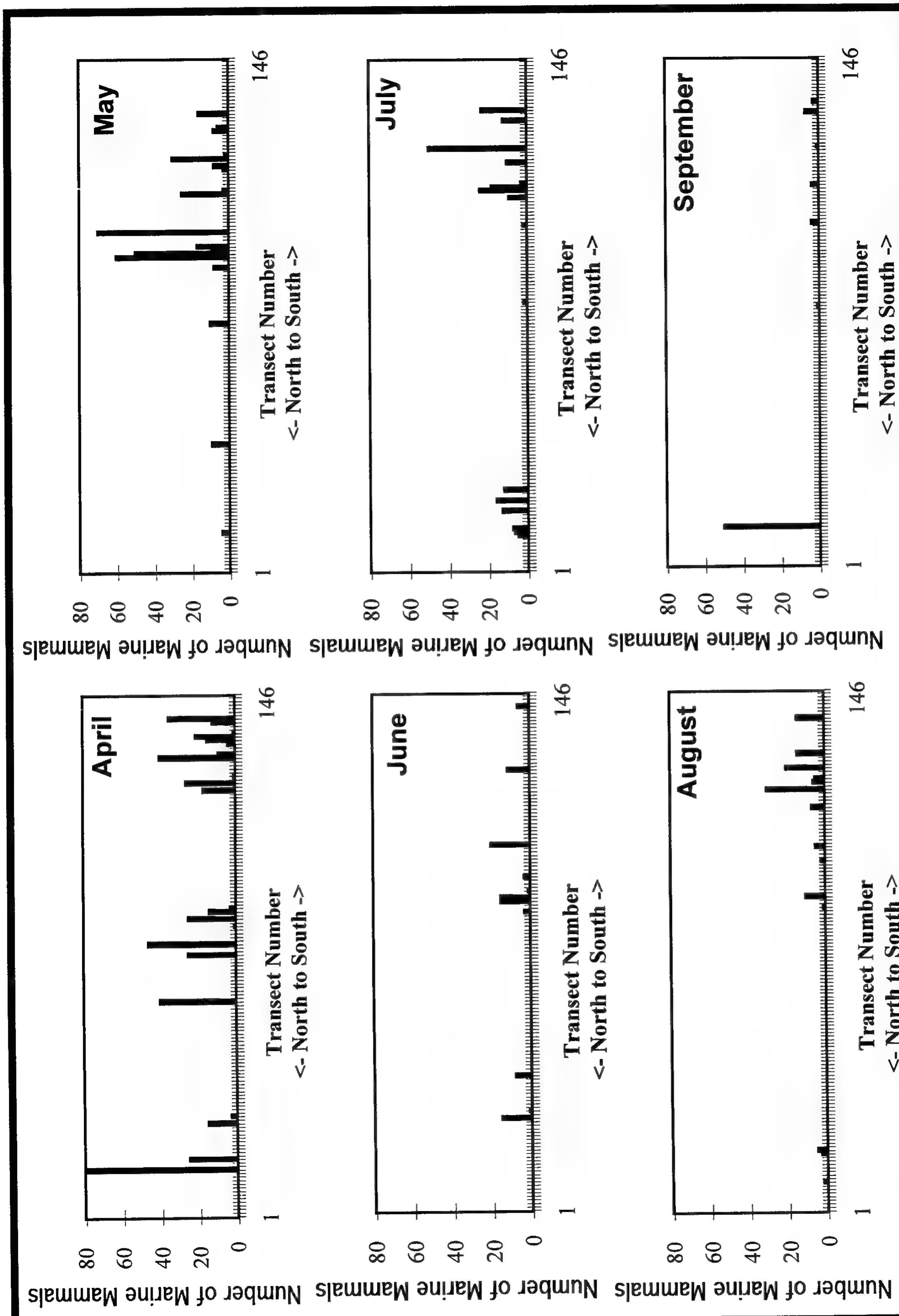


Figure 3-3. Marine mammal abundance along individual transects at the Mayport area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

Norfolk

Based on historical records, 34 marine mammal species may occur at the Norfolk area, including 7 baleen whales, 26 toothed whales and dolphins, and 1 seal (**Table 3-1**). Of these, 11 species are considered likely to occur (presence probable): fin whale, minke whale, sei whale, humpback whale, pilot whale, Atlantic spotted dolphin, bottlenose dolphin, pantropical spotted dolphin, common dolphin, Risso's dolphin, and spinner dolphin. The other 23 species could occur in the area but are not especially likely to be found there (presence possible).

A total of 4,438 individuals representing at least 14 species of marine mammals were seen at the Norfolk area during the 1995 aerial surveys. Observed densities of marine mammals (all species combined) averaged about 50 individuals/100 km^2, and adjusted densities averaged about 280 individuals/100 km^2. About one-third of the mammals observed were pilot whales. Other abundant species were Atlantic spotted dolphin, bottlenose dolphin, pantropical spotted dolphin, common dolphin, and Risso's dolphin.

Marine mammal densities at the Norfolk area were higher than at Mayport during all surveys (**Figure 3-2**). Densities at the Norfolk area were highest during the May, June, July, and August surveys. In part, this pattern is due to the abundance of pilot whales, which were most numerous during June, July, and August, especially within the southern half of the area.

Figure 3-4 shows the abundance of marine mammals along individual transects at the Norfolk area. Numbers of marine mammals on a transect ranged from 0 to 250 individuals. During May through August surveys, about half of the transects had one or more marine mammals present, but during April and September, most transects had none. Marine mammals were generally more abundant in the southern half of the area.

Six of the marine mammals potentially occurring at Norfolk are listed as endangered as defined by the Endangered Species Act of 1973. These are the blue whale, fin whale, humpback whale, northern right whale, sei whale, and sperm whale. Four of these species (fin whale, humpback whale, sei whale, and sperm whale) were observed during April through July surveys. Fin whales were the most common large whale seen. No endangered species were seen during surveys after July, when it is presumed that these animals migrated to northern feeding grounds. No critical habitat for endangered marine mammal species is located near the Norfolk area.

One additional marine mammal, the harbor porpoise, has been proposed for listing as a threatened species (Appendix C). The harbor porpoise is primarily a coastal species that is not likely to occur at the Norfolk area, and none of these animals were seen during the 1995 aerial surveys.

Of 23 species with historical distributional records indicating "presence possible," 20 were not seen during the 1995 aerial surveys. This includes 3 species of baleen whales, 16 species of toothed whales and dolphins, and 1 species of seal. Species such as dwarf and pygmy sperm whales (*Kogia* spp.) were not seen, although

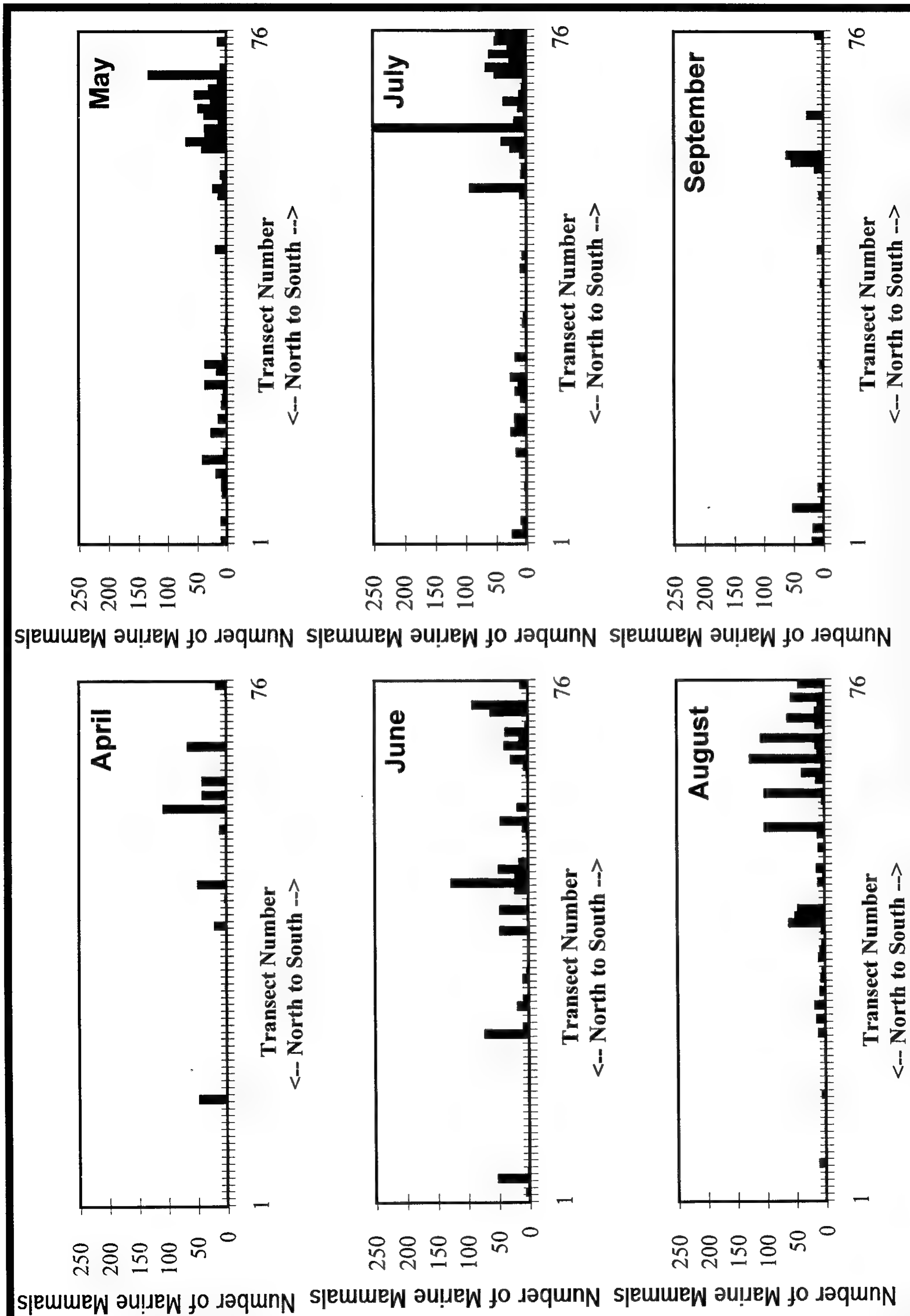


Figure 3-4. Marine mammal abundance along individual transects at the Norfolk area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

they occur frequently in stranding reports from the southeastern U.S. (Tyack, 1996). The absence of these species may be due to factors such as low abundance, seasonality of occurrence, depth and/or habitat preferences outside of the area, year-to-year variability, and behavioral traits such as aircraft avoidance and short surface times in deep diving species.

3.2.4 Sea Turtles

Five sea turtle species may occur at either the Mayport or Norfolk area: loggerhead, leatherback, green, hawksbill, and Kemp's ridley. **Table 3-2** summarizes the status and historical presence of each species and provides density estimates based on 1995 aerial surveys. All five species are currently classified as either endangered or threatened under the Endangered Species Act of 1973. Species descriptions are provided in Appendix B.

Historical records suggest that loggerhead and leatherback sea turtles are likely to be the most common at either area; both loggerheads and leatherbacks inhabit pelagic (offshore) waters as adults. The three other turtle species (green, hawksbill, and Kemp's ridley) are typically found inshore and were not seen during 1995 aerial surveys (see below).

To supplement historical information, monthly aerial surveys were conducted at the Mayport and Norfolk areas from April through September 1995 (Department of the Navy, 1995b). Methods have been described above under Marine Mammals. Observed densities from aerial surveys do not take into account submerged individuals or those that may have been on the surface but undetected. Therefore, adjusted densities were developed for each species as explained in Appendix B. Adjusted densities are about 33 times higher than observed densities, reflecting the fact that only about 10% of the sea turtle population is believed to be on the surface at a given time (Nelson et al., 1987; Thompson, 1995) and only about 30% of animals on the surface are believed to be detected from the air. Juveniles and smaller subadults are difficult to detect from the air, especially if associated with *Sargassum* or other flotsam. Loggerhead hatchlings are known to associate with *Sargassum* to facilitate their movement (Schwartz, 1988).

Figure 3-5 shows observed and adjusted densities of sea turtles at Mayport and Norfolk based on the 1995 aerial surveys.

Mayport

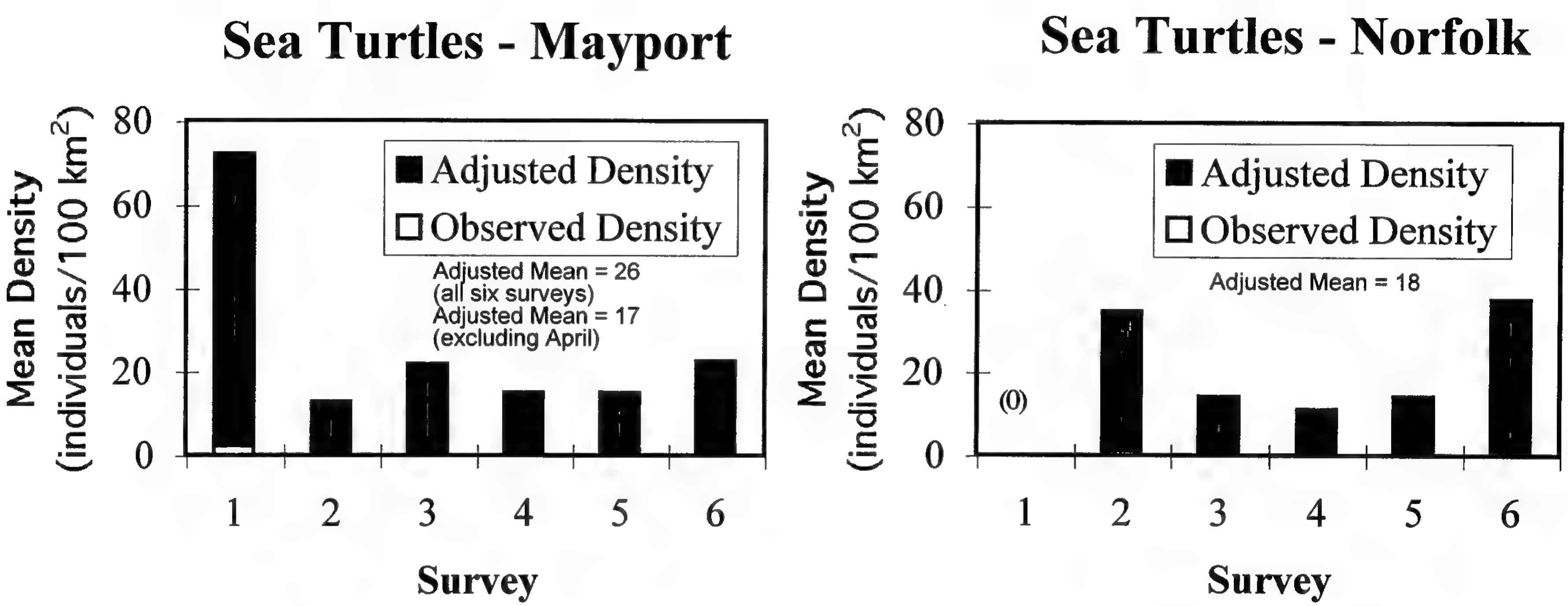
A total of 138 sea turtles were seen during the aerial surveys at the Mayport area. Of the total, 128 were loggerheads, 6 were leatherbacks, and 4 were unidentified. Based on all six surveys, observed mean densities of sea turtles were 0.78 individuals/100 km^2, and adjusted mean densities were about 26 individuals/100 km^2. Because there would be no shock testing in April at Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April). For the May-September period, observed mean densities were 0.52 individuals/100 km^2 and adjusted mean densities were about 17 individuals/100 km^2.

Table 3-2. Status, historical presence, and densities of sea turtles potentially occurring at the Mayport and Norfolk areas.

Common and Scientific Name	Status[a]	Historical Presence[b]		Observed Mean Density From 1995 Aerial Surveys[c] (Individuals/100 km²)			Adjusted Mean Density[d] (Individuals/100 km²)		
		Mayport	Norfolk	Mayport	Mayport (excluding April)	Norfolk	Mayport	Mayport (excluding April)	Norfolk
Loggerhead turtle (*Caretta caretta*)	T	++	++	0.72	0.46	0.50	24.12	15.15	16.63
Leatherback turtle (*Dermochelys coriacea*)	E	++	++	0.03	0.04	0.01	0.94	1.13	0.31
Unidentified hardshell turtle	NA	NA	NA	0.02	0.02	0.03	0.69	0.62	1.03
Green turtle (*Chelonia mydas*)	T	+	+	0	0	0	0	0	0
Hawksbill turtle (*Eretmochelys imbricata*)	E	+	+	0	0	0	0	0	0
Kemp's ridley turtle (*Lepidochelys kempii*)	E	+	+	0	0	0	0	0	0
TOTAL SEA TURTLES (rounded to nearest whole number)				**1** (0.78)	**1** (0.52)	**1** (0.54)	**26** (25.75)	**17** (16.90)	**18** (17.97)

NA = not applicable.

a Status: E = endangered species, T = threatened species.
b Historical Presence: ++ = presence probable based on historical sightings data; + = presence possible based on historical sightings data, but a depth or latitudinal limit may exist. Sources: Prichard and Marquez, 1973; Schwartz, 1978; Carr et al., 1979; Crouse, 1980, 1988; Lee and Palmer, 1981; CETAP, 1982; Murphy and Hopkins, 1984; Musick et al., 1984; Lee, 1985a; Lund, 1985; Lutcavage and Musick, 1985; Musick, 1986; Henwood and Ogren, 1987; Schroeder and Thompson, 1987; Dodd, 1988; Epperly and Veishlow, 1989; Knowlton and Weigle, 1989; Continental Shelf Associates, Inc., 1990; Marquez, 1990; NMFS and USFWS, 1991a,b, 1992a,b, 1993; USFWS, 1991; Meylan, 1992; Thompson and Huang, 1993.
c Observed mean densities are from six aerial surveys conducted during April-September 1995 (Department of the Navy, 1995c). Mean densities (individuals/100 km²) are based on total individuals sighted ÷ area surveyed (2,948 km² at Mayport or 1,470 km² at Norfolk) ÷ 6 surveys × 100. Because there would be no testing in April in Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April).
d Adjusted densities take into account estimated numbers of submerged individuals and those that may have been undetected on the surface. Appendix B explains how adjusted densities were calculated for each species. Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data.



Note: Observed densities are too small to be visible except on Mayport Survey 1 (April).

Figure 3-5. Sea turtle densities at the Mayport and Norfolk areas, based on six aerial surveys conducted during April through September 1995 (Data from: Department of the Navy, 1995b). Observed densities were adjusted to account for submerged and undetected individuals as explained in Appendix B.

Sea turtle densities at Mayport were highest during the first survey (April 1995) but showed no pattern during the rest of the surveys (**Figure 3-5**). About half of all the loggerheads counted during the surveys were seen during April. The high abundance during April may have been due to turtles converging on nearshore areas prior to nesting. Most loggerheads nest between May and September on the beaches of southeast Florida, with other nesting areas located in Georgia, South Carolina, and North Carolina, as well as the Gulf coast of Florida. The eggs hatch in about two months, and hatchlings swim offshore where they inhabit *Sargassum* rafts. In the vicinity of the Mayport area, adult loggerhead turtles reportedly concentrate within middle shelf waters and are rarely seen in the Gulf Stream and associated deeper waters (Schroeder and Thompson, 1987).

Figure 3-6 shows the abundance of sea turtles along individual transects at the Mayport area. Numbers of turtles on a transect ranged from 0 to 5 individuals; within any given survey (and especially during May through September), most transects had zero. Sea turtle abundance and frequency of occurrence was greatest during April and lowest during May. Sea turtles were generally more abundant and widespread in the southern half of the area during May, July, and August, but during the other months, there was no strong north-south pattern.

Due to the high abundance of sea turtles during April at Mayport, it would be difficult to find a test site with no turtles present (**Figure 3-6**). Therefore, if Mayport is chosen as the area for shock testing, there would be no testing during April (see Section 2.2.3.1).

Norfolk

A total of 48 sea turtles were seen during the aerial surveys at the Norfolk area. Of the total, 44 were loggerheads, 1 was a leatherback, and 3 were unidentified. Observed mean densities (all species combined) were 0.54 individuals/100 km^2, and adjusted mean densities were about 18 individuals/100 km^2.

No sea turtles were seen at the Norfolk area during the first survey (April 1995) (**Figure 3-3**). Among the other surveys, densities were higher in May and September and lower in June, July, and August. Low densities during summer months may be due to movement of the turtle population inshore for nesting; Dodd (1988) reported nesting of loggerheads occurring along North Carolina beaches between April and late August.

Figure 3-7 shows the abundance of sea turtles along individual transects at the Norfolk area. Numbers of turtles on a transect ranged from 0 to 3 individuals; within any given survey, most transects had zero. Sea turtle abundance and frequency of occurrence was greatest during May and September; during June, July, and August, there were only a few sightings.

As noted above, most of the turtles seen during aerial surveys were loggerheads. This is consistent with results reported by Epperly et al. (1995), who found that loggerheads made up most or all of the accidental sea turtle catch by trawlers in North Carolina offshore waters. This is the only turtle species commonly found nesting along mid-Atlantic beaches.

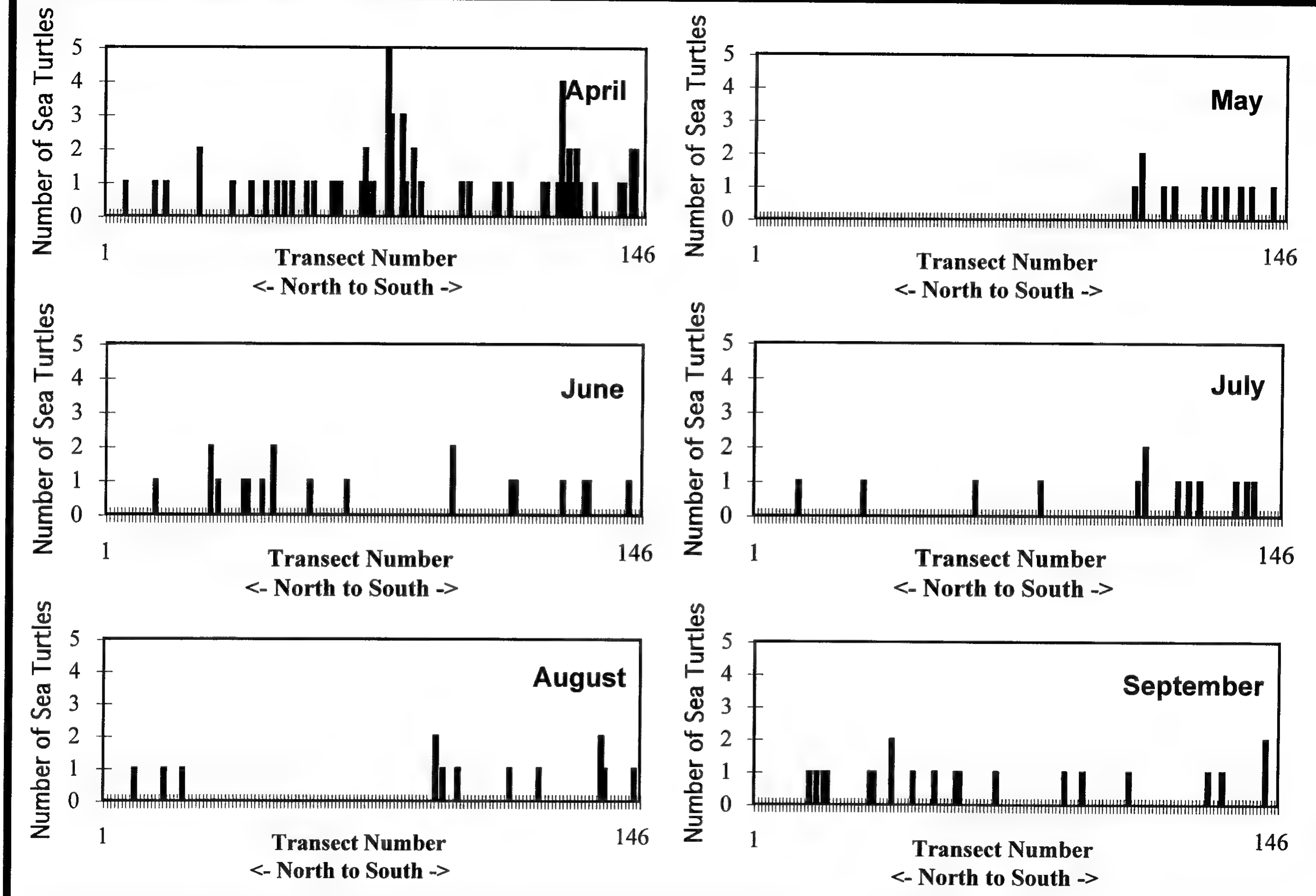


Figure 3-6. Sea turtle abundance along individual transects at the Mayport area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

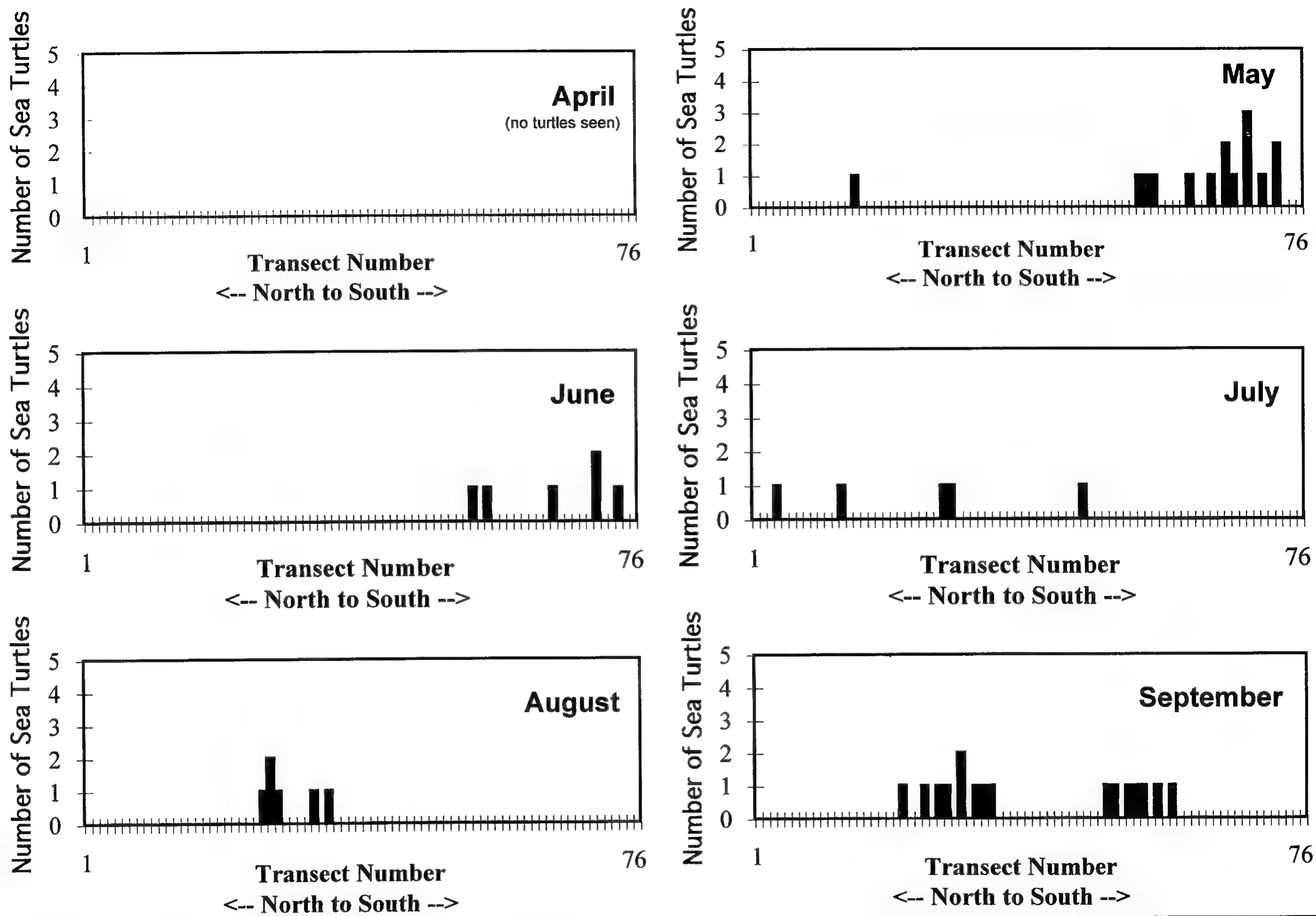


Figure 3-7. Sea turtle abundance along individual transects at the Norfolk area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

3.2.5 Benthos

3.2.5.1 Invertebrates

Mayport

Infauna are animals that live within the sediment. Infaunal communities along the shelf edge near the Mayport area typically have low density and biomass and high species diversity. Worms (polychaetes) account for more than 50% of total numbers and biomass in most samples (Texas Instruments, Inc., 1979; Marine Resources Research Institute, 1985). Species composition changes mainly with water depth and to a lesser extent with latitude (Marine Resources Research Institute, 1985). Low benthic biomass in this area may be due to overall low nutrient input resulting from the presence of a salinity front approximately 20 km (11 nmi) offshore (Texas Instruments, Inc., 1979).

Epifauna are animals that live on the sediment. The Mayport area is situated near the boundary between two distinct epifaunal zones: the outer shelf and the deep slope (Texas Instruments, Inc., 1979). The density and biomass of epifaunal invertebrates collected along the middle and outer shelf of this area varies with water depth, latitude, and season. Water depth appears to be more important than latitude in determining density and biomass. Crustaceans are generally the most conspicuous and abundant group of soft bottom epifauna (Texas Instruments, Inc., 1979; Marine Resources Research Institute, 1985). Several commercially important crustacean species including shrimp and the golden deepsea crab (*Chaceon fenneri*) are patchily distributed along the shelf and shelf edge within the vicinity of the area. Other principal groups include molluscs, echinoderms (e.g., starfish and sea biscuits), and anthozoans (e.g., sea anemones). The distribution of epifauna in the area appears to be governed largely by hydrographic patterns and the intermittent influence of Gulf Stream intrusions or eddies (Texas Instruments, Inc., 1979).

Norfolk

Infaunal communities near the Norfolk area are numerically dominated by four major groups: molluscs, echinoderms, annelid worms, and crustaceans (Wigley and Theroux, 1981; Steimle, 1990). Molluscs (primarily clams) were the most abundant group found near the area, and were distributed in a series of broad bands parallel to the coastline across the shelf and slope throughout the region. A high density band was found in the vicinity of the Norfolk area along the shelf edge and slope. Echinoderms (primarily brittle stars) were found in moderately high densities along the central and outer shelf. Annelid worms were widely distributed in all subareas of the region, though distribution was comparatively sparse within the area offshore of Chesapeake Bay. Crustaceans (particularly amphipods) are one of the most common groups found within shelf waters. Densities and biomass near the Norfolk area are about three times lower than those seen in from shallower depths.

Other abundant epifauna in this area included sponges and sea anemones. Wigley and Theroux (1981) reported that sponges were found in small areas scattered throughout the shelf edge offshore of Chesapeake Bay. Sea anemones were broadly distributed in low densities from Cape Cod to Cape Hatteras, particularly on the shelf

edge and slope. The mean density of all coelenterates between 100 and 200 m (328 and 656 ft) in the vicinity of the area was 155 individuals/m^2.

The abundance and biomass of benthic organisms generally decrease with increasing water depth (Virginia Institute of Marine Science, 1979; Wigley and Theroux, 1981). The most pronounced changes in density were observed at or near the shelf edge. This trend may be due to the complex effects of hydrography (primarily temperature) and changing sediment characteristics with variations in shelf topography (Virginia Institute of Marine Science, 1979). Due to the relatively narrow shelf in this area, biomass of macrobenthos was found to be relatively small (as compared to stations to the north) and showed little difference with respect to depth across the shelf (Wigley and Theroux, 1981). Biomass levels in this area fluctuate seasonally, with peaks generally occurring in summer (Steimle, 1990). This seasonal component, however, appears to decrease with increasing depth (Virginia Institute of Marine Science, 1979).

3.2.5.2 Demersal Fish

Mayport

The demersal (bottom) fish assemblage of the Mayport area reflects the transition in benthic habitat from outer shelf to upper slope. The outer shelf supports over 140 demersal fish numerically dominated by croakers and drums, lefteye flounders, searobins, and lizardfish (Struhsaker, 1969; George and Staiger, 1979; Miller and Richards, 1980; Wenner et al., 1980; Low et al., 1982). Although some members of these families could occur in the water depth of the Mayport area, most inhabit shallower shelf waters.

Wenner et al. (1980) identified a distinctive group of fish from outer shelf/upper slope waters ranging from 111 to 366 m (364 to 1,200 ft) deep. This group included slender searobin, morid cod, pygmy argentine, spotted hake, Gulf Stream flounder, blackmouth bass, spinycheek bass, tilefish, shortnose greeneye, and blackbelly rosefish. With the exception of the tilefish (an important fishery species), the ecology of these species is not well known. Tilefish inhabit a narrow depth range of 100 to 290 m (328 to 950 ft) where they occupy burrows constructed in clay bottoms (Grossman et al., 1985; Able et al., 1993).

Four of the sites sampled by Wenner et al. (1980) offshore of southern Georgia were near the Mayport area. Several species at these sampling sites such as round scad, dusky flounder, smallmouth flounder, and snakefish are wide ranging and commonly found in middle and outer shelf waters, while others such as beardfish, red barbier, streamer searobin, and shortnose greeneye are restricted to outer shelf/upper slope waters.

Norfolk

The demersal (bottom) fish fauna of the continental shelf in the area of the Norfolk area consists of about 130 species (Ross, 1985). The distribution and abundance of demersal fish over the shelf are influenced primarily by water depth and temperature (Grosslein, 1976; Grosslein and Azarovitz, 1982; Colvocoresses and Musick, 1984). The demersal fauna is a dynamic combination of year-round resident species, warm

temperate species that migrate northward into the area in spring, and boreal (northern) species that migrate southward into the area in fall. Warm temperate species living on the outer shelf in the vicinity of the Norfolk area include scup, black seabass, summer flounder, spotted hake, butterfish, and northern searobin. Boreal species moving into the outer shelf area during fall include silver hake, goosefish, and red hake. On the upper slope, shortnose greeneye, blackbelly rosefish, and white hake occur in most collections from the area regardless of season and are considered upper slope residents (Musick, 1979; Colvocoresses and Musick, 1984).

3.2.6 Seabirds

The seabird fauna at the Mayport and Norfolk areas is similar because both areas are in offshore waters of the mid-Atlantic and southeastern U.S. Range, habitat, and general life history information for seabirds which may occur at the Mayport and Norfolk areas are summarized in Appendix B. The U.S. Fish and Wildlife Service (USFWS) has determined that no federally listed (endangered or threatened) bird species or their critical habitat are present at either area (see Appendix C).

Common seabirds found offshore of the mid-Atlantic and southeastern U.S. include representatives of the orders Charadriiformes (alcids, gulls, phalaropes, skuas, terns), Pelecaniformes (boobies, frigatebirds, gannets, tropicbirds), and Procellariiformes (albatrosses, petrels, shearwaters, storm petrels) (Clapp et al., 1982a,b, 1983; Hoopes et al., 1994; Lee, 1984, 1985b, 1986; Lee and Palmer, 1981; Lee and Socci, 1989). These seabirds include seasonal migrants and year-round residents, and they may feed on or below the sea surface. A significant portion of the seabird populations at the Norfolk area aggregate seasonally off the Outer Banks.

Coastal and offshore waters of the eastern U.S. also serve as a major migratory corridor for many other species of birds, such as shorebirds of the order Charadriiformes (plovers, sanderlings, sandpipers, willets) and coastal and terrestrial birds (National Geographic Society, 1987; Lee and Horner, 1989). These include, but are not restricted to the following groups: Anseriformes (ducks, geese), Ciconiiformes (egrets, herons, ibises), Falconiformes (falcons, hawks, ospreys), Gruiformes (coots, gallinules, rails), Passeriformes (crows, flycatchers, kinglets, sparrows, swallows, warblers, wrens), Pelicaniformes (cormorants, pelicans), and Podicepideformes (grebes). Most of these species are typically found inshore and do not feed or rest on the sea surface.

3.3 SOCIOECONOMIC ENVIRONMENT

3.3.1 Commercial and Recreational Fisheries

Table 3-3 summarizes the types of commercial and recreational fishing activities that take place at or near the Mayport and Norfolk areas. Landings data for both regions have been summarized by the Department of the Navy (1995a). Due to the way landings are reported, it is not possible to calculate how much of the regional catch comes from the specific locations of the Mayport and Norfolk areas.

Table 3-3. Commercial and recreational fishing activities occurring at or near the Mayport and Norfolk areas.

Fishing Method	Species Sought	
	Mayport	Norfolk
Commercial Fishing		
Surface longlining	Sharks, swordfish, tunas	Sharks, swordfish, tunas
Bottom longlining	Golden tilefish	Golden tilefish (mainly north of the site)
Bottom trawling	---	Summer flounder, black seabass, butterfish, hake, squid (trawling occurs mainly during winter)
Recreational Fishing		
Trolling	Billfishes, dolphinfish, tunas, wahoo	Billfishes, dolphinfish, tunas, wahoo

Mayport

Most commercial and recreational fisheries such as shrimp trawling, reef fishing, and king mackerel fishing take place inshore of the area. However, certain species, particularly oceanic pelagic and deep reef species, known to occur in the vicinity of the Mayport area are sought by commercial and recreational fishers.

Commercial fishers work the offshore waters of northeastern Florida for sharks, swordfish, and tunas. These species are caught with surface drifting longlines fished in the water column offshore of the shelf break. Longlines are set near the western edge of the Gulf Stream often with the aid of sophisticated onboard temperature sensors, depth finders, and positioning equipment. Longline sets can measure several nautical miles with up to 1,000 hooks per set. Bottom longlining for golden tilefish also occurs off Mayport.

Recreational anglers who travel to the Mayport area are seeking oceanic pelagic and to a lesser extent deep reef species. Despite the considerable minimum distance to the area from Mayport, some private and charter sport fishers regularly venture this far offshore to troll for billfish, dolphinfish, tunas, and wahoo. Most fishing occurs between the depths of 91 to 305 m (300 to 1,000 ft) (Furr, 1995).

Norfolk

Bottom trawling and surface longlining are the major commercial fisheries expected in the vicinity of the Norfolk area. Although the trawl fishery targets summer flounder, there is considerable bycatch of other species including black seabass, butterfish, and hake (Ross et al., 1988). This fishery takes place in fall and winter months in outer shelf waters from 40 to 100 m (131 to 328 ft) deep, just inshore of the Norfolk area. Squid (short-finned and long-finned), also taken by trawl, are fished in inner-shelf waters during spring and summer and outer-shelf waters during winter. Surface longlining produces sharks, swordfish, and tunas from waters of the shelf edge and seaward depending upon oceanic conditions (Taniguchi, 1987). Bottom longlining for golden tilefish also occurs in the area, but mainly to the north of the area (from Norfolk Canyon north).

Recreational anglers seeking oceanic gamefish (e.g., billfish and tunas) may fish the waters near the Norfolk area (Richards, 1965; Figley, 1988). In 1983, there were 455 vessels (415 private, 40 charter) in Virginia's marlin and tuna sportfishing fleet. Figley (1988) reported that most middle Atlantic offshore fishermen restricted their activities to the area from Norfolk Canyon (which is north of the Norfolk area) northward to Block Canyon.

Charter and private boat fishermen operating off Virginia's eastern shore [out to the 183 m (600 ft) depth contour] catch dolphinfish, little tunny, skipjack tuna, yellowfin tuna, Atlantic bonito, and white marlin (Richards, 1965; Figley, 1988). In addition, blue marlin, swordfish, bigeye tuna, and albacore are also taken. The Norfolk area falls within these ranges and given the depth preferences of these fish, they may periodically be found at the area. Most of the charter boat catch, particularly for the more offshore waters, occurs between late April and mid-October. This is the period when weather

permits the long excursions offshore to fish for these open water fish, and coincides with the occurrence of the fish in the area.

3.3.2 Other Socioeconomic Topics

Ship traffic near the Mayport and Norfolk areas has been discussed under Operational Requirements in Section 2.2.2.1. Other socioeconomic topics such as shipwrecks, offshore dredged material disposal sites, and marine sanctuaries are not discussed because they are not present in the area or are being avoided by the proposed action (see Section 2.2.2.2). A subsea communication cable crosses the Mayport area (National Oceanic and Atmospheric Administration, 1991), but its use was discontinued in 1993 (Wargo, 1994). Onshore socioeconomics are not discussed because existing facilities at Naval Station Mayport, Naval Submarine Base Kings Bay, and Naval Station Norfolk are more than adequate to handle all required services in support of shock testing.

4.0 ENVIRONMENTAL CONSEQUENCES

This section analyzes potential impacts of shock testing the SEAWOLF at two alternative offshore areas: Mayport, Florida and Norfolk, Virginia. The impact discussion focuses on significant issues identified through the scoping process. Other issues that do not require detailed analysis are discussed briefly at the beginning of each major subsection.

Because both areas are along the east coast at the same water depth and about the same distance from shore, potential impacts are similar. To avoid redundancy, separate sections for Mayport and Norfolk are not presented. Instead, potential impacts at the two areas are contrasted within each major subsection.

Mitigation to minimize risk to marine mammals and turtles is taken into account in the impact analysis. Protective measures including test site selection and pre- and post-detonation monitoring are described in Section 5.0.

Potential radiological environmental effects from shock testing the SEAWOLF submarine are evaluated in Appendix F. The appendix provides information on the Naval Nuclear Propulsion Program which, pursuant to federal law, regulates nuclear safety and radioactivity associated with nuclear propulsion work. The Program provides comprehensive technical management of all aspects of Navy nuclear propulsion plant design, construction, and operation including careful consideration of reactor safety and radiological and environmental concerns. Past operations, including shock tests, have resulted in no significant radiological environmental impacts and demonstrated the Program's effectiveness. Continued application of the environmental practices which are standard throughout the Program will ensure the absence of any radiological environmental effect as a result of shock testing the SEAWOLF submarine.

Impact discussions are divided into separate subsections to distinguish between those aspects of the proposed action evaluated under NEPA and those evaluated under Executive Order 12114. As discussed in Section 1.4, NEPA applies to activities and impacts within U.S. territory, whereas Executive Order 12114 applies to activities and impacts outside territorial seas. The proposed action includes operations that would occur both within and outside U.S. territory. Shock testing and associated mitigation operations would occur at least 78 km (42 nmi) offshore at the Mayport area or 54 km (29 nmi) at the Norfolk area, well outside U.S. territorial seas. No impacts from the actual test (detonation of explosives) would occur in U.S. territory. The only operations that would occur within territorial limits are shore support activities and vessel and aircraft movements in territorial waters (i.e., transits between the shore base and the offshore shock testing site). These shore support activities and vessel and aircraft movements are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases.

4.1 IMPACTS UNDER NEPA

4.1.1 Physical Environment

Shore support operations and movement of vessels and aircraft within territorial limits are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Impacts of these existing operations on geology and sediments, air quality, and water quality are minimal, and no additional direct impacts are expected at either Mayport or Norfolk.

Chemical byproducts of the detonations would be rapidly dispersed at the test site (see Sections 4.2.1.2 and 4.2.1.3) and therefore would not affect coastal water quality or air quality.

Due to the water depth of the explosion (30 m or 100 ft) and the distance from nearest shore [78 km (42 nmi) for Mayport and 54 km (29 nmi) for Norfolk), the detonations are expected to be virtually inaudible to human populations onshore, except in the event of unusual atmospheric conditions such as thermal inversions and low clouds. An underwater explosion generates the most noise when it takes place just below the surface. According to O'Keeffe and Young (1984), a reasonable assumption is that one can disregard the noise from explosions at reduced depths equal to or greater than 2.0 $ft/lb^{1/3}$, which in this case yields a depth of 13 m (43 ft), much less than the depth of the proposed detonations.

4.1.2 Biological Environment

Shore support operations and movement of vessels and aircraft within territorial limits are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Impacts of these existing operations on marine biota, including plankton, pelagic fish, marine mammals, sea turtles, benthic organisms, and seabirds are minimal, and no additional direct or indirect impacts are expected at either Mayport or Norfolk.

4.1.3 Socioeconomic Environment

Shore support operations and movement of vessels and aircraft within territorial limits are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Impacts of these existing operations on commercial and recreational fisheries and ship traffic are minimal, and no additional direct or indirect impacts are expected at either Mayport or Norfolk.

Existing facilities at Naval Station Mayport and Naval Submarine Base Kings Bay or Naval Station Norfolk would provide most services in support of shock testing. The only additional facilities required would be temporary offices (five to six rented trailers), an instrumentation trailer, and possibly a small supply trailer (cable, spare parts, etc.) (see Section 2.2.1). Additional space would be leased outside the base, if required. No significant direct or indirect impacts on the local economy are expected at Mayport, Kings Bay, or Norfolk.

Due to the small area affected and the short duration of shock testing, the proposed action would not have significant impacts on commercial or recreational fishery stocks or fishing activities (see Section 4.2.3.1). Therefore, no significant impacts on the coastal fishing industry are expected.

Public concerns were expressed during scoping meetings that dead fish might wash ashore and affect tourism. A large fish kill would not be expected during SEAWOLF shock testing because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0). Large fish kills have not been seen following previous similar detonations (Department of the Navy, 1981; Naval Air Warfare Center, 1994). Any fish killed or injured by the explosions are most likely to drift to the northeast with the Gulf Stream. Due to the distance from shore and the strong currents, it is highly unlikely that dead fish would reach shore. Oceanographic modeling for a location a similar distance from the North Carolina coast has shown there is a <1% chance of floating material reaching shore (DOI, MMS, 1990). Therefore, no significant onshore or nearshore impacts from fish kills are expected.

4.2 IMPACTS UNDER EXECUTIVE ORDER 12114

4.2.1 Physical Environment

4.2.1.1 Geology and Sediments

Both the Mayport and Norfolk areas are predominantly sand bottom at this water depth. Potential impacts at the two areas should be similar.

Calculations based on the size of the explosive (4,536 kg or 10,000 lb), the depth of burst (30 m or 100 ft), and the total water depth (152 m or 500 ft) indicate there would be no cratering of the seafloor (Young, 1995b). The shock wave would reach the seafloor and be reflected from it, but would have no significant impact on bottom structure or form. The reflected wave would probably carry some resuspended sediment which would settle to the seafloor. Fragments of steel charge casings would settle to the bottom, but would have no significant impact on bottom structure or form. The largest possible fragment from the explosion is the top plate and crossbar, which together weigh 204 kg (450 lb).

4.2.1.2 Air Quality and Noise

The alternative areas (Mayport and Norfolk) are well offshore and are located in an area that is not classified for priority pollutants under the Clean Air Act. Therefore, a Clean Air Act General Conformity Review is not applicable. Ambient air quality and impacts are expected to be similar at the two areas.

The spherical bubble produced by each explosion would expand to a maximum radius of 19 m (62.3 ft) (Young, 1995a). The bubble would migrate upward and collapse beneath the surface, where it would re-expand and emerge into the atmosphere. The water that is ejected would form a roughly hemispherical mass of plumes with an estimated maximum height of 165 m (540 ft). It is estimated that 90% of the gaseous explosion products would become airborne.

Airborne explosion products are assumed to stabilize in a spherical form and move downwind, with concentrations remaining the same for the first 30 m (100 ft) (Young, 1995a). This "cloud" would not be visible. Then, the airborne cloud would continue to move at the speed of the wind and become diluted and dispersed by atmospheric turbulence.

Table 4-1 lists initial and downwind concentrations of explosion products in the atmosphere. The calculations assume that the products would be uniformly mixed at the time of stabilization and that the cloud would expand as a result of natural turbulence (Young, 1995a).

There are no air quality standards developed specifically for underwater explosions. For comparison, limits used by the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH), and the National Institute for Occupational Safety and Health (NIOSH) can be used (**Table 4-1**). Relevant standards include the Ceiling Concentration (CL), which cannot be exceeded at any time; and the Short-Term Exposure Limit (STEL), which is usually a 15-minute time-weighted average. Limits are not given for asphyxiants, which are non-toxic gases that exclude oxygen from the lungs when present in high concentrations.

All of the predicted initial concentrations (except for carbon monoxide and ammonia) are below the OSHA, ACGIH, and NIOSH limits. For safety reasons, no personnel would be near the detonation point where the highest concentrations would occur. The initial concentrations would disperse rapidly in the atmosphere; all predicted concentrations would be well below the limits at 305 m (1,000 ft) downwind, a point which would be reached within a few minutes after detonation depending on wind speed (e.g., within 2 minutes in a 5-kt wind). Because of the low initial concentrations and rapid dispersion of explosion products, there would not be any risk to human health or marine life in the test site.

Personnel in ship spaces below the water line and all personnel in the submarine would be provided hearing protection. Potential noise impacts on marine mammals and turtles are discussed separately below in Sections 4.2.2.3 and 4.2.2.4.

4.2.1.3 Water Quality

Ambient water quality at the Mayport and Norfolk areas is similar because both are located in deep oceanic waters at the edge of the Gulf Stream. Impacts of shock testing on water quality would be similar at the two areas.

Chemical products of deep underwater explosions are initially confined to a thin, circular area called the surface pool. It is estimated that 100% of the solid explosion products and 10% of the gases remain in the pool (Young, 1995a). This surface pool is fed by an upwelling current of water entrained by the rising bubble produced by the detonation. After the turbulence of the explosion has dispersed, the pool stabilizes and chemical products become uniformly distributed. The surface pool is usually not visible after about five minutes. As the pool continues to grow, the chemical products are diluted

Table 4-1. Atmospheric concentrations of explosion products compared with atmospheric exposure standards (Adapted from: Young, 1995a). Concentrations are based on a 4,536 kg (10,000 lb) HBX-1 charge detonated at 30 m (100 ft) below the sea surface.

Explosion Product	Concentration (ppm)			Exposure Standard (ppm except where noted)		
	Initial	305 m (1,000 ft) Downwind	1,524 m (5,000 ft) Downwind	OSHA PEL	ACGIH TLV	NIOSH REL
Carbon dioxide (CO_2)	37.9	1.2	0.107	--[a]	STEL: 30,000	CL: 30,000
Carbon monoxide (CO)	672	21.2	1.90	--[a]	STEL: 400	CL: 200
Ammonia (NH_3)	86.4	2.73	0.245	--[a]	STEL: 35	CL: 50
Ethane (C_2H_6)	100	3.16	0.283	Asphyxiant	Asphyxiant	Asphyxiant
Propane (C_3H_8)	19.6	0.619	0.0555	--[a]	Asphyxiant	--
Hydrogen cyanide (HCN)	7.06	0.223	0.0200	--[a]	CL: 10	CL: 5 mg CN/m^3/10M
Methane (CH_4)	5.03	0.159	0.0142	Asphyxiant	Asphyxiant	Asphyxiant
Methyl alcohol (CH_3OH)	0.205	0.0065	0.0006	--[a]	STEL: 250	CL: 800/15M
Formaldehyde (CH_2O)	0.108	0.0034	0.0003	--[a]	--[a]	--
Acetylene (C_2H_2)	0.161	0.0051	0.0005	CL: 2,500	Asphyxiant	CL: 2,500
Phosphine (PH_3)	0.171	0.0054	0.0005	--[a]	STEL: 1	--

Abbreviations:
OSHA = Occupational Safety and Health Administration; PEL = permissible exposure limit.
ACGIH = American Conference of Governmental Industrial Hygienists; TLV = threshold limit value.
NIOSH = National Institute for Occupational Safety and Health; REL = recommended exposure limit.
CL = ceiling concentration; STEL = short-term exposure limit.

a The only limit specified is a time-weighted average for an 8-hr day, 40-hr work week. This would not be relevant to the proposed detonations.

and become undetectable. Because of continued dispersion and mixing, there would be no buildup of explosion products in the water column.

Table 4-2 lists predicted water column concentrations of explosion products in the surface pool at the time of stabilization (Young, 1995a). The table compares the concentrations with water quality criteria developed to protect marine or human life. The EPA (1986) has published water quality criteria for ammonia and cyanide, but not for the other explosion products. The two solids, carbon and aluminum oxide, are both found in nature and are not hazardous materials. For the other products, criteria to protect marine life (Suter and Rosen, 1988) or humans (Sittig, 1985) were used. All of the predicted concentrations are below the criteria, indicating no hazard to marine life.

4.2.2 Biological Environment

4.2.2.1 Plankton

Plankton at either Mayport or Norfolk would be affected mainly by the physical force of the shock wave from the proposed detonations. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3).

Physical effects would be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (**Figure 4-1**). This is a region of near total physical trauma within which no organisms would be expected to survive. The maximum lateral extent of the cavitation region is estimated at 494 m (1,620 ft) for a 4,536 kg (10,000 lb) charge (Appendix D). This region would extend from the surface to a depth of about 24 m (80 ft). Due to the rapid replenishment of plankton through population growth and/or turbulent mixing with adjacent waters, no lasting impacts on plankton communities are expected at either the Mayport or Norfolk area.

Sargassum communities (described in Section 3.2.1.2) are an important component of the plankton because this seaweed provides habitat for juvenile sea turtles. Although plankton is not a main focus of mitigation efforts, detonation is unlikely to occur if large rafts of *Sargassum* are present. As part of the mitigation plan, *Sargassum* clumps spotted from the air would be investigated by surface observers to determine whether juvenile sea turtles were present (see Section 5.0). Detonation would be postponed if turtles were found within the safety range.

4.2.2.2 Pelagic Fish

The proposed underwater detonations could have two main effects on pelagic (water column) fish. First, fish within a certain radius would be killed or injured by the resulting shock waves. A large fish kill would not be expected because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0). Second, fish at greater distances may react behaviorally to sound impulses from the blasts. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous

Table 4-2. Predicted concentrations of explosion products in seawater, compared with permissible concentrations (Adapted from: Young, 1995a). Predicted concentrations are for the surface pool at the time of stabilization. Permissible concentrations are based on reference standards for marine life (U.S. Environmental Protection Agency, 1986; Suter and Rosen, 1988). In cases where marine life criteria have not been established, values for humans were used (Sittig, 1985).

Explosion Product	Predicted Concentration (mg/L)	Permissible Concentration (mg/L)
Carbon dioxide (CO_2)	0.00113	1.0[a]
Carbon monoxide (CO)	0.0127	0.552
Ammonia (NH_3)	0.001	0.092[b]
Ethane (C_2H_6)	0.00203	120
Propane (C_3H_8)	0.000586	120
Hydrogen cyanide (HCN)	0.000129	0.001[b] 0.036[c]
Methane (CH_4)	0.0000546	120
Methyl alcohol (CH_3OH)	0.00000446	3.60
Formaldehyde (CH_2O)	0.00000221	0.0414
Carbon (C)	0.0621	NA
Acetylene (C_2H_2)	0.00000285	73
Phosphine (PH_3)	0.00000394	0.0055
Aluminum oxide (Al_2O_3)	0.189	NA

a 1.0 mg/L produces avoidance by fish.
b Water quality criterion from U.S. Environmental Protection Agency (1986).
c Maximum acceptable toxicant concentration for fish exposed to cyanide (Suter and Rosen, 1988).

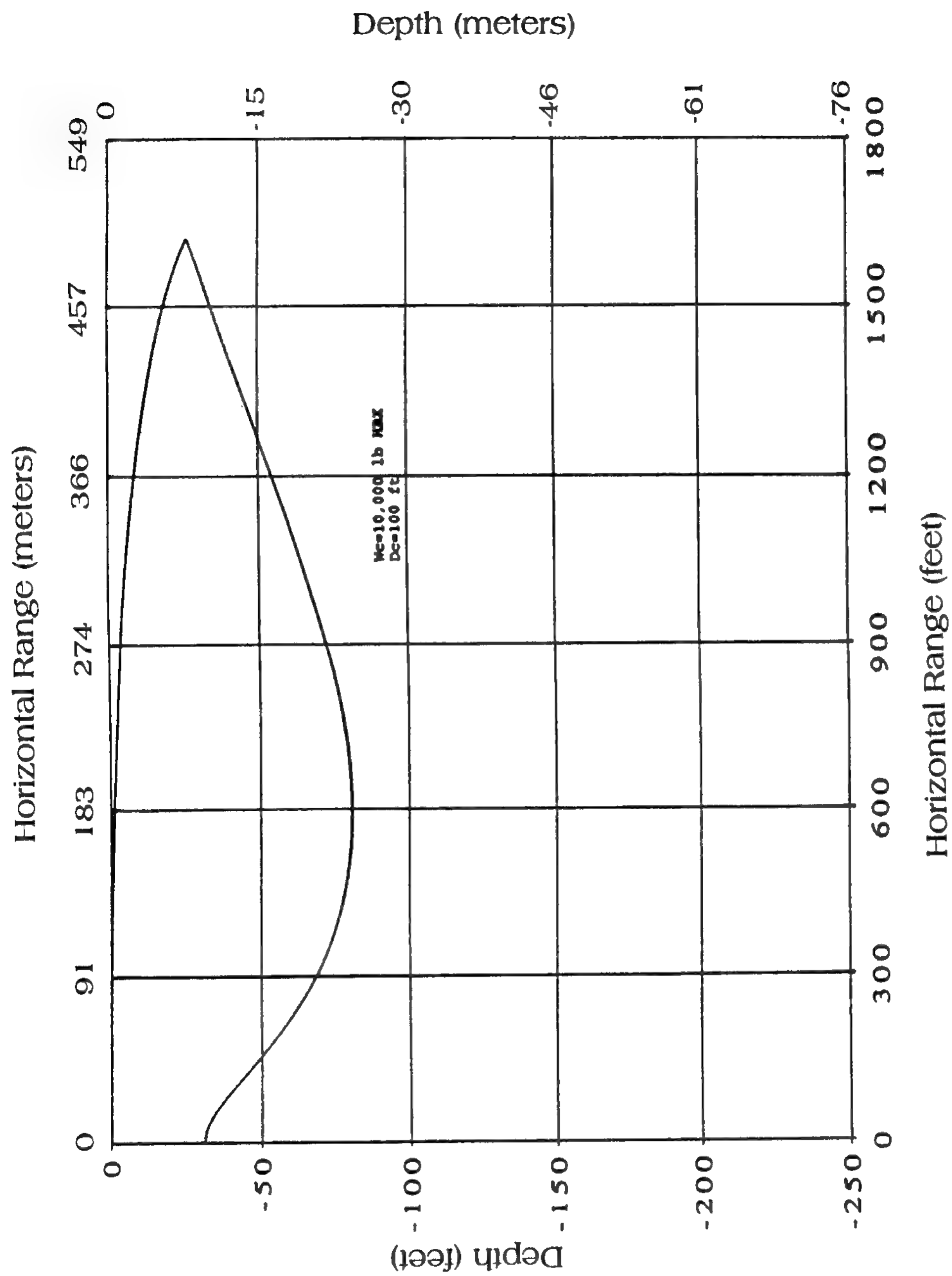


Figure 4-1. Bulk cavitation region for a 4,536-kg (10,000-lb) charge (From: Appendix D).

to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3). Potential impacts on demersal (bottom) fish are discussed separately under Benthos (Section 4.2.2.5).

Mortality and Injury

Effects of underwater explosions on fish have been studied extensively (Yelverton et al., 1975; O'Keeffe and Young, 1984; Young, 1991; Goertner et al., 1994). Studies have shown that the fish most vulnerable to death and injury are those with swimbladders. A swimbladder is a gas-filled organ used to control buoyancy. Most commercial and recreational fishery species are in this category. Fish without swimbladders, such as sharks and flatfish, generally are very resistant to explosions (Goertner et al., 1994). Vulnerability also depends on fish size and shape; smaller fish and those that are laterally compressed are more susceptible to injury.

Based on theoretical models and experimental evidence, Young (1991) developed equations to predict a 10% mortality range for fish (i.e., a distance beyond which at least 90% of fish would survive). **Table 4-3** lists the 10% mortality range for pelagic fish expected to occur at the Mayport and Norfolk areas. Most species could occur at both areas, so the impacts should be similar. The distances range from 22 m (73 ft) for non-swimbladder fish to over 914 m (3,000 ft) for some of the small swimbladder fish. The latter species, such as dwarf herring, round scad, Atlantic menhaden, alewife, chub mackerel, butterfish, and bluefish are the ones most likely to be injured or killed by the blasts if they are present at the site during testing.

Schooling and non-schooling fish may differ in vulnerability. Non-schooling species are usually widely dispersed, and few individuals are likely to be present at the test site. Most oceanic pelagic fish are non-schooling; exceptions are dolphinfish, tunas, and occasionally wahoo. For schooling fish, it is more likely that either several or none could be killed. Most coastal pelagic fish, including the small swimbladder species, are schooling fish. However, detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0).

It is not possible to accurately estimate the number of fish that would be within the 10% mortality range, because the abundance of fish in the open ocean is extremely variable. Monitoring following detonation of a 4,536 kg (10,000 lb) charge for the shock trial of the USS JOHN PAUL JONES revealed about 100 dead fish (Naval Air Warfare Center, 1994). Previous observations following explosives testing near Key West, Florida have shown "very few" floating dead fish (Department of the Navy, 1981).

Although the number of fish that would be killed or injured is not known, overall impacts on individual species are expected to be insignificant based on the relatively small area affected. The area within the 10% mortality range would represent only a small percentage of the offshore habitat at this water depth. The area within 1 nmi to either side of the 152 m (500 ft) depth contour is about 730 km^2 (213 nmi^2) at Mayport and 490 km^2 (143 nmi^2) at Norfolk. From Table 4-3, the maximum radius of the 10% mortality range is 1.42 km (4,653 ft, or 0.77 nmi). The area within this radius is 6.32 km^2 (1.84 nmi^2), which is less than 1% of the total area at Mayport and just over 1% of the total area at Norfolk. Pelagic fish species are widely distributed and are not restricted to

Table 4-3. Estimated 10% mortality range for pelagic fish at the Mayport and Norfolk areas. The 10% mortality range is the distance from the detonation point beyond which 90% or more of the fish would survive. Calculations are based on Young (1991), assuming a 4,536 kg (10,000 lb) charge detonated 30 m (100 ft) below the sea surface.

Common Name	Occurrence		Swim Bladder	Schooling	Fish Weight (lb)	10% Mortality Range (ft)
	Mayport	Norfolk				
Oceanic Pelagic Fish						
Dolphin	X	X	yes	yes	10	2,557
Wahoo	X	X	yes	occasionally	20	2,337
Sailfish	X	X	yes	no	40	2,135
White marlin	X	X	yes	no	50	2,074
Tunas	X	X	yes (reduced in some)	yes	60	2,026
Swordfish	X	X	yes	no	150	1,798
Blue marlin	X	X	yes	no	250	1,683
Sharks	X	X	no	no	100	73
Coastal Pelagic Fish						
Dwarf herring	X	--	yes	yes	0.1	4,653
Round scad	X	--	yes	yes	0.25	4,130
Atlantic menhaden	X	X	yes	yes	0.5	3,774
Alewife	--	X	yes	yes	0.5	3,774
Chub mackerel	X	X	yes	yes	1	3,449
Butterfish	X	X	yes	yes	1.75	3,207
Bluefish	X	X	yes	yes	2-20	2,337-3,152
Jacks	X	X	yes	yes	8	2,632
Cobia	X	X	yes	yes	20	2,337
Atlantic mackerel	X	X	no	no	2	73
Spanish mackerel	X	X	no	yes	2	73
Little tunny	X	X	no	yes	9	73
King mackerel	X	X	no	yes	15	73
Requiem sharks	X	X	no	yes	50	73

the Mayport and Norfolk areas; therefore much less than 1% of the population is likely to be affected.

The distances listed in **Table 4-3** apply to fish near the surface, where the reflected shock wave produces a region of negative pressure. Pelagic fish in deeper water or near the bottom could survive much closer to the blast. These fish would experience only the direct, positive pressure wave and reflections from the bottom. Under these conditions, there would not be much difference in survival between swimbladder and non-swimbladder species. Effects on demersal (bottom) fish are discussed separately in Section 4.2.2.5.

Behavioral Responses

Fish can hear and react to sounds (Popper and Fay, 1993). Hearing ability (frequency range and sensitivity) differs greatly among species. Fish with a swimbladder connected to the inner ear, such as herring, or other anatomical adaptations generally have the best hearing.

Effects of low-frequency sound pulses on fish have been reviewed by BBN Systems and Technologies (1993). The review included several studies of airgun blasts (Chapman and Hawkins, 1969; Dalen and Raknes, 1985; Pearson et al., 1992; Skalski et al., 1992). Such sound pulses have been shown to produce behavioral responses such as avoidance, alarm, and startle reactions, and may temporarily affect schooling behavior. The review concluded that sound pulses at levels of 160 dB may cause subtle changes in behavior, and stronger pulses (180 dB) could cause more noticeable changes. For a 4,536 kg (10,000 lb) charge, sound pressure levels of 180 dB could occur within a radius of about 2.6 to 3.7 km (1.4 to 2.0 nmi) from the detonation point (Department of the Navy, 1993). An energy-based criterion, such as the one developed for marine mammals in Appendix E, has not been developed for fish.

Similar fish species occur at the Mayport and Norfolk areas, so the effects should be similar. Any behavioral responses to low-frequency sounds from the underwater explosions would be short term and reversible. Unlike the airgun blasts cited above, detonations during SEAWOLF shock testing would be five single events occurring at about one-week intervals. Fish behavior should return to normal within minutes after each explosion. No lasting effect on schooling behavior or catchability (for fishery species) is expected.

4.2.2.3 Marine Mammals

Two main types of potential direct impacts on marine mammals are discussed here. First, animals may be killed or injured if they are present near the detonation point and not detected during pre-test monitoring. Second, animals at greater distances may experience temporary acoustic discomfort. Behavioral responses and possible indirect impacts to marine mammals are also discussed. Appendices D and E present technical calculations concerning potential mortality, injury, and acoustic discomfort of marine mammals.

In addition to these main effects, there are several minor issues that do not require detailed analysis. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3). Minor increases in vessel and air traffic are not a major concern from the standpoint of marine mammal harassment because of built-in mitigation measures (use of shipboard observers; limited transit speed; and flights at approved altitudes).

Because the proposed action may result in mortality or injury of marine mammals, the Navy is submitting a request for an "incidental take" authorization from the NMFS. The Marine Mammal Protection Act of 1972 allows the incidental (but not intentional) taking of marine mammals upon request if the taking will (1) have a negligible impact on the species or stock(s); and (2) not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. If the NMFS determines that these conditions are met, the agency would issue a Letter of Authorization for incidental take, which would include permissible take limitations and required mitigation measures.

In addition, because listed (endangered or threatened) species of marine mammals and sea turtles may occur at the Mayport or Norfolk areas, formal consultation with the NMFS is required under the Endangered Species Act. This DEIS includes a Biological Assessment (Appendix G) which will be submitted to the NMFS. Based on this information, the NMFS will issue a Biological Opinion taking into account the cumulative impacts of all activities potentially affecting listed marine mammal and turtle populations. The proposed action cannot occur unless the Biological Opinion concludes that shock testing is not likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat.

The proposed action includes mitigation that would minimize risk to marine mammals (see Section 5.0). The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If post-detonation monitoring showed that marine mammals or turtles were killed or injured as a result of a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

The safety range radius of 3.79 km (2.05 nmi) was calculated using information on eardrum rupture, which is the most conservative measure of non-lethal injury discussed in Appendix D. The maximum predicted horizontal distance for a 10% probability of eardrum rupture for a marine mammal is 3.79 km (2.05 nmi). Aerial and acoustic monitoring would extend beyond the safety range to ensure that no marine mammal could enter the safety range prior to detonation (see Section 5.0). The safety range radius is more than twice the maximum range for lethality.

Overview of Impact Analysis

The actual numbers of marine mammals that may be killed, injured, or experience acoustic discomfort as a result of SEAWOLF shock testing cannot be known in advance. Previous experience during the shock trial of the USS JOHN PAUL JONES, which involved detonation of two 4,536 kg (10,000 lb) charges, showed there were no marine mammal deaths or injuries despite marine mammal densities that were significantly higher than those observed at either Mayport or Norfolk (Naval Air Warfare Center, 1994). Similar mitigation methods are proposed for the SEAWOLF shock testing (see Section 5.0). In addition, based on the patchy distribution of marine mammals at the Mayport and Norfolk areas as shown in Figures 3-3 and 3-4, the Navy expects to be able to select a specific test site with few, if any, marine mammals present.

However, it is necessary to estimate numbers of potentially affected animals to (1) provide a basis for comparing alternative areas in this DEIS and (2) provide numbers for the incidental take request that will be submitted to the NMFS in accordance with the Marine Mammal Protection Act. If an incidental take permit is issued by NMFS, the numbers of marine mammals specified in the permit cannot be exceeded. Therefore, this analysis deliberately overestimates numbers of affected animals in order to provide an upper bound on potential impacts. Because the same assumptions and methods are used for both Mayport and Norfolk, the analysis is appropriate for comparing the alternative areas.

The number of marine mammals potentially killed, injured, or experiencing acoustic discomfort as a result of the proposed detonations was estimated using a series of steps and assumptions:

1. Maximum ranges for mortality, injury, and acoustic discomfort were defined using criteria developed in Appendices D and E, as explained later in this section. The acoustic discomfort criterion is based on data from humans, and the mortality and injury criteria are based on tests conducted with other terrestrial mammals. The models developed to apply these data to marine mammals are believed to be "conservative;" that is, they include a margin of safety to avoid underestimating the effect range.

2. These maximum ranges were used to define concentric circles around the detonation point (**Figure 4-2**), and to calculate the area within each circle. The area of the injury range was corrected by subtracting the area of the mortality range to avoid double-counting mortality and injury; i.e., if an animal were killed, it should not also be counted as injured. Similarly, the uncorrected area of the injury range was subtracted from the acoustic discomfort range. Resulting areas were as follows:
   - Mortality range: 7.30 km^2 (2.13 nmi^2)
   - Injury range: 37.87 km^2 (11.03 nmi^2)
   - Acoustic discomfort range: 342.70 km^2 (99.78 nmi^2)

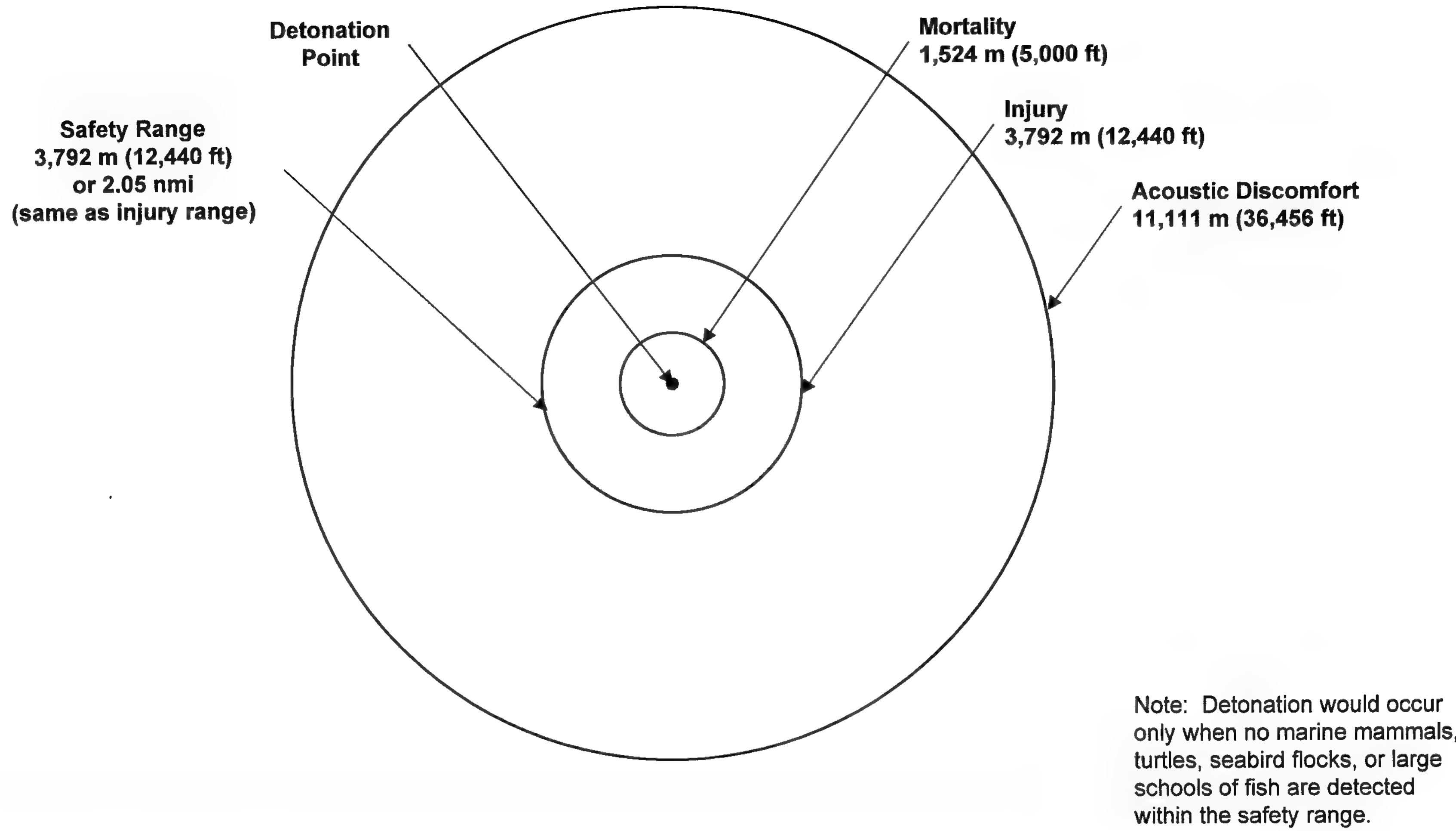


Figure 4-2. Maximum horizontal ranges for mortality, injury, and acoustic discomfort in relation to the safety range for mitigation efforts.

3. Mean densities of each species were multiplied by the area of the mortality, injury, and acoustic discomfort ranges to estimate the number of mammals affected "without mitigation" for a single detonation. Mean densities were taken from Section 3.2.3 and are based on 1995 aerial survey counts adjusted for submerged and undetected individuals.

4. Mitigation effectiveness was estimated for each species, taking into account the probability of detection by aerial and surface observers and passive acoustic monitoring (see Appendix B). For mortality and injury, the "without mitigation" numbers for each species were then multiplied by (1 minus mitigation effectiveness), which is the probability of not detecting that species during pre-detonation monitoring. The resulting values are the expected number of undetected animals of each species within the mortality and injury ranges.

5. For acoustic discomfort, the "with mitigation" numbers were assumed to be equal to the "without mitigation" numbers, because only animals outside the safety range would be affected.

6. The mortality, injury, and acoustic discomfort estimates for a single detonation were multiplied by five to account for the five detonations that would occur during SEAWOLF shock testing. Species historically present at or near each area but not seen during 1995 aerial surveys were each assigned a value of one individual for acoustic discomfort. This value is similar to those calculated for the least abundant species observed during 1995 aerial surveys. The results were totalled and then rounded up to the nearest whole number.

There are several key assumptions. First, it was assumed that marine mammal densities during shock testing would be similar to those during 1995 aerial surveys. Although this may or may not hold true, the 1995 observations are the best quantitative data available for both areas. Also, other species with historical sightings from the Mayport or Norfolk areas were taken into account by assuming one individual of each of these species would experience acoustic discomfort. Second, it was assumed that the mean density for a whole area (Mayport or Norfolk) can be used to predict the expected number of animals that would occur within a small test site. This assumption overestimates impacts, because the abundance of marine mammals is patchy within both areas (see Figures 3-3 and 3-4) and the Navy proposes to select an operationally suitable test site with the lowest possible density of marine mammals and turtles (i.e., much lower than the mean density for the area as a whole). Finally, the estimates of detectability (mitigation effectiveness) for each species are assumed to be accurate. These numbers were developed through a logical process that included consultation with and review by marine mammal experts (see Appendix B).

Results of the calculations are presented in **Tables 4-4 and 4-5** for Mayport and Norfolk, respectively.

Table 4-4. Estimates of potential marine mammal mortality, injury, and acoustic discomfort from shock testing at the Mayport area, with and without mitigation. Shock testing would only be conducted "with mitigation," including no testing in April at Mayport. Numbers are given to two decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Mayport during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
BALEEN WHALES										
* Blue whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Bryde's whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Fin whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Humpback whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Minke whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Northern right whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Sei whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
TOOTHED WHALES AND DOLPHINS										
Atlantic spotted dolphin	0.21	1.10	9.95	0.93	0.01	0.08	9.95	0.08	0.40	49.73
Bottlenose dolphin	0.21	1.11	10.07	0.93	0.02	0.08	10.07	0.08	0.40	50.37
Bottlenose/Atlantic spotted dolphin	0.07	0.37	3.36	0.93	0.01	0.03	3.36	0.03	0.14	16.79
Clymene/spinner/striped dolphin	0.05	0.27	2.45	0.96	<0.01	0.01	2.45	0.01	0.05	12.27
Pantropical spotted dolphin	0.63	3.27	29.58	0.93	0.05	0.24	29.58	0.23	1.19	147.89
Risso's dolphin	0.48	2.50	22.60	0.93	0.03	0.18	22.60	0.17	0.90	113.02
Sperm whale (E)	0.01	0.06	0.52	0.81	<0.01	0.01	0.52	0.01	0.05	2.58
Spinner dolphin	0.14	0.71	6.46	0.96	0.01	0.03	6.46	0.02	0.13	32.29
Unidentified dolphin	0.52	2.68	24.28	0.93	0.04	0.19	24.28	0.19	0.97	121.42

Table 4-4. (Continued).

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
* Blainville's beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Clymene dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Common dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Cuvier's beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Dwarf sperm whale	0	0	0.20	NA	0	0	0.20	0	0	1
* False killer whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Fraser's dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Gervais' beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Killer whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Melon-headed whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Pilot whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Pygmy killer whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Pygmy sperm whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Rough-toothed dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Striped dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* True's beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
TOTAL	2.33	12.07	109.27	0.93[d]	0.16	0.85	109.27	**1** (0.82)	**5** (4.23)	**570** (569.36)

(E) = endangered species. NA = not applicable. * = species historically present in the region but not seen at the Mayport area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.3) for May through September at Mayport, scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).
b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).
c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).
d Overall mitigation effectiveness was calculated as 1 minus (total with mitigation/total without mitigation).

Table 4-5. Estimates of potential marine mammal mortality, injury, and acoustic discomfort from shock testing at the Norfolk area, with and without mitigation. Shock testing would only be conducted "with mitigation." Numbers are given to two decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Norfolk during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[c] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
BALEEN WHALES										
Fin whale (E)	0.21	1.10	9.93	0.89	0.02	0.12	9.93	0.12	0.60	49.65
Humpback whale (E)	0.01	0.02	0.22	0.89	<0.01	<0.01	0.22	<0.01	0.01	1.08
Minke whale	0.02	0.10	0.86	0.43	0.01	0.05	0.86	0.05	0.27	4.32
Sei whale (E)	0.01	0.05	0.43	0.89	<0.01	0.01	0.43	0.01	0.03	2.16
Sei or Bryde's whale	0.01	0.02	0.22	0.89	<0.01	<0.01	0.22	<0.01	0.01	1.08
Unidentified *Balaenoptera* sp.	0.05	0.29	2.59	0.89	0.01	0.03	2.59	0.03	0.16	12.95
Unidentified baleen whale	0.02	0.09	0.86	0.89	<0.01	0.01	0.86	0.01	0.05	4.32
* Blue whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Bryde's whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Northern right whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
TOOTHED WHALES AND DOLPHINS										
Atlantic spotted dolphin	3.79	19.65	177.87	0.93	0.28	1.43	177.87	1.37	7.13	889.34
Bottlenose dolphin	2.36	12.26	110.95	0.93	0.17	0.89	110.95	0.86	4.44	554.76
Bottlenose/Atl. spotted dolphin	0.29	1.53	13.82	0.93	0.02	0.11	13.82	0.11	0.55	69.07
Clymene/spinner/striped dolphin	1.13	5.84	52.88	0.96	0.04	0.21	52.88	0.20	1.06	264.43
Common dolphin	1.42	7.39	66.92	0.93	0.10	0.54	66.92	0.52	2.68	334.58
Cuvier's beaked whale	0.02	0.09	0.86	0.43	0.01	0.05	0.86	0.05	0.27	4.32
Pantropical spotted dolphin	2.00	10.38	93.90	0.93	0.15	0.75	93.90	0.72	3.76	469.49
Pilot whale	6.32	32.82	297.02	0.93	0.46	2.38	297.02	2.29	11.90	1485.11
Risso's dolphin	0.55	2.84	25.69	0.93	0.04	0.21	25.69	0.20	1.03	128.44
Sperm whale (E)	0.04	0.19	1.73	0.81	0.01	0.04	1.73	0.04	0.18	8.63
Spinner dolphin	0.28	1.48	13.38	0.96	0.01	0.05	13.38	0.05	0.27	66.92
Striped dolphin	0.11	0.57	5.18	0.96	<0.01	0.02	5.18	0.02	0.10	25.90
Unidentified dolphin	1.77	9.21	83.32	0.93	0.13	0.67	83.32	0.64	3.34	416.61

Table 4-5. (Continued).

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[c] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
Unidentified small whale	0.02	0.12	1.08	0.93	<0.01	0.01	1.08	0.01	0.04	5.40
* Atlantic white-sided dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Blainville's beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Clymene dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Dwarf sperm whale	0	0	0.20	NA	0	0	0.20	0	0	1
* False killer whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Fraser's dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Gervais' beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Harbor porpoise	0	0	0.20	NA	0	0	0.20	0	0	1
* Killer whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Melon-headed whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Northern bottlenose whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Pygmy killer whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Pygmy sperm whale	0	0	0.20	NA	0	0	0.20	0	0	1
* Rough-toothed dolphin	0	0	0.20	NA	0	0	0.20	0	0	1
* Sowerby's beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
* True's beaked whale	0	0	0.20	NA	0	0	0.20	0	0	1
PINNIPEDS										
* Harbor seal	0	0	0.20	NA	0	0	0.20	0	0	1
TOTAL	20.43	106.04	963.71	0.93[d]	1.46	7.58	963.71	**8** (7.30)	**38** (37.88)	**4,819** (4818.55)

(E) = endangered species. NA = not applicable. * = species historically present in the region but not seen at the Norfolk area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.3) for April through September at Norfolk, scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).

b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).

c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

d Overall mitigation effectiveness was calculated as 1 minus (total with mitigation/total without mitigation).

Mortality and Injury

Marine mammals can be killed or injured by underwater explosions due to the response of air cavities, such as the lungs and bubbles in the intestines, to the shock wave (Yelverton et al., 1973; Hill, 1978; Goertner, 1982). Effects are likely to be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (**Figure 4-1**). This is a region of near total physical trauma within which no animals would be expected to survive. Based on calculations in Appendix D, the maximum horizontal extent of the cavitation region is estimated at 494 m (1,620 ft) for the proposed detonations. This region would extend from the surface to a maximum depth of about 24 m (80 ft).

A second measure of possible mortality (and the one which is used here) is the maximum range for the onset of extensive lung hemorrhage. Extensive lung hemorrhage is considered debilitating and potentially fatal; suffocation caused by lung hemorrhage is likely to be the major cause of marine mammal death from underwater shock waves, based on experiments with terrestrial mammals (Hill, 1978). Appendix D presents calculations which estimate the maximum range for the onset of extensive lung hemorrhage to marine mammals. The range varies depending on mammal weight, with the smallest mammals having the greatest range. The maximum range predicted for a small marine mammal is 1,524 m (5,000 ft) from the detonation point (**Figure 4-3**). This value is more conservative than the estimated lethal range of 70 to 800 m (230 to 2,625 ft) calculated by Ketten (1994) for the same size charge. *For purposes of impact analysis, it was assumed that 100% of the marine mammals within 1,524 m (5,000 ft) of the detonation point would be killed, even though the probability of mortality from extensive lung hemorrhage is estimated to be only 1% at the outer edge of this range.*

Two measures of non-lethal injury are also discussed in Appendix D: slight lung hemorrhage and eardrum rupture. These are injuries from which animals would be expected to recover on their own. The maximum range for slight lung hemorrhage is 1,850 m (6,069 ft). The maximum range for 10% probability of eardrum rupture varies from 2,408 m (7,900 ft) to 3,792 m (12,440 ft) depending on mammal depth in the water column. The latter value is for a mammal at the bottom (**Figure 4-4**). The 10% eardrum rupture range at the bottom was used as the maximum range for non-lethal injury. *For purposes of impact analysis, it was assumed that 100% of marine mammals between 1,524 m (5,000 ft) and 3,792 m (12,440 ft) from the detonation point would be injured, even though the probability of eardrum rupture at the outer edge of this range is only 10% (and less in near-surface waters).*

It is recognized that some percentage of the animals with eardrum rupture or slight lung hemorrhage could eventually die from their injuries. However, this is taken into account by the mortality criterion discussed above (onset of extensive lung hemorrhage), which deliberately overestimates mortality by assuming 100% of animals within a radius of 1,524 m (5,000 ft) would be killed. At this radius, the probability of eardrum rupture is 50% or less in the upper water column and 50% to 95% in deeper water (see Figure 11 in Appendix D); i.e., all animals within this radius are assumed to be killed even though some animals might not even have eardrum rupture.

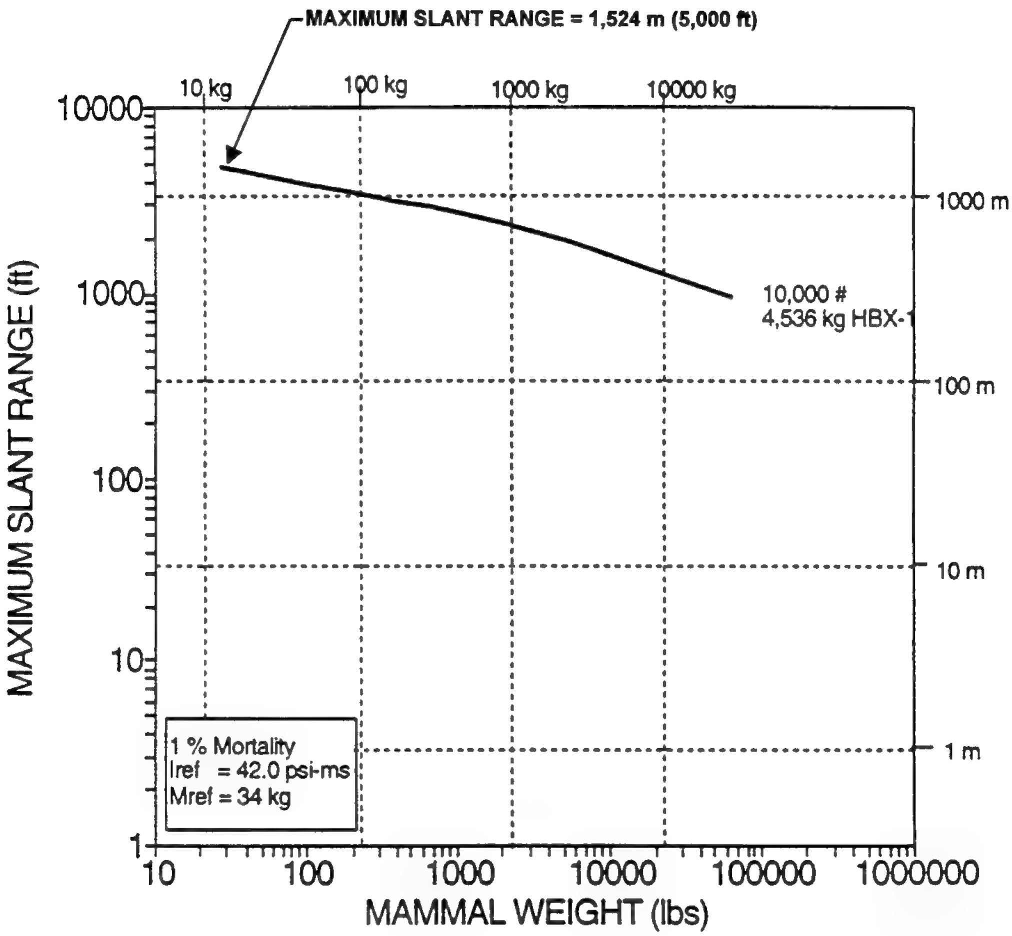


Figure 4-3. Maximum calculated ranges for 1% mortality (onset of extensive lung hemorrhage) as a function of mammal weight for a 4,536-kg (10,000-lb) charge (From: Appendix D).

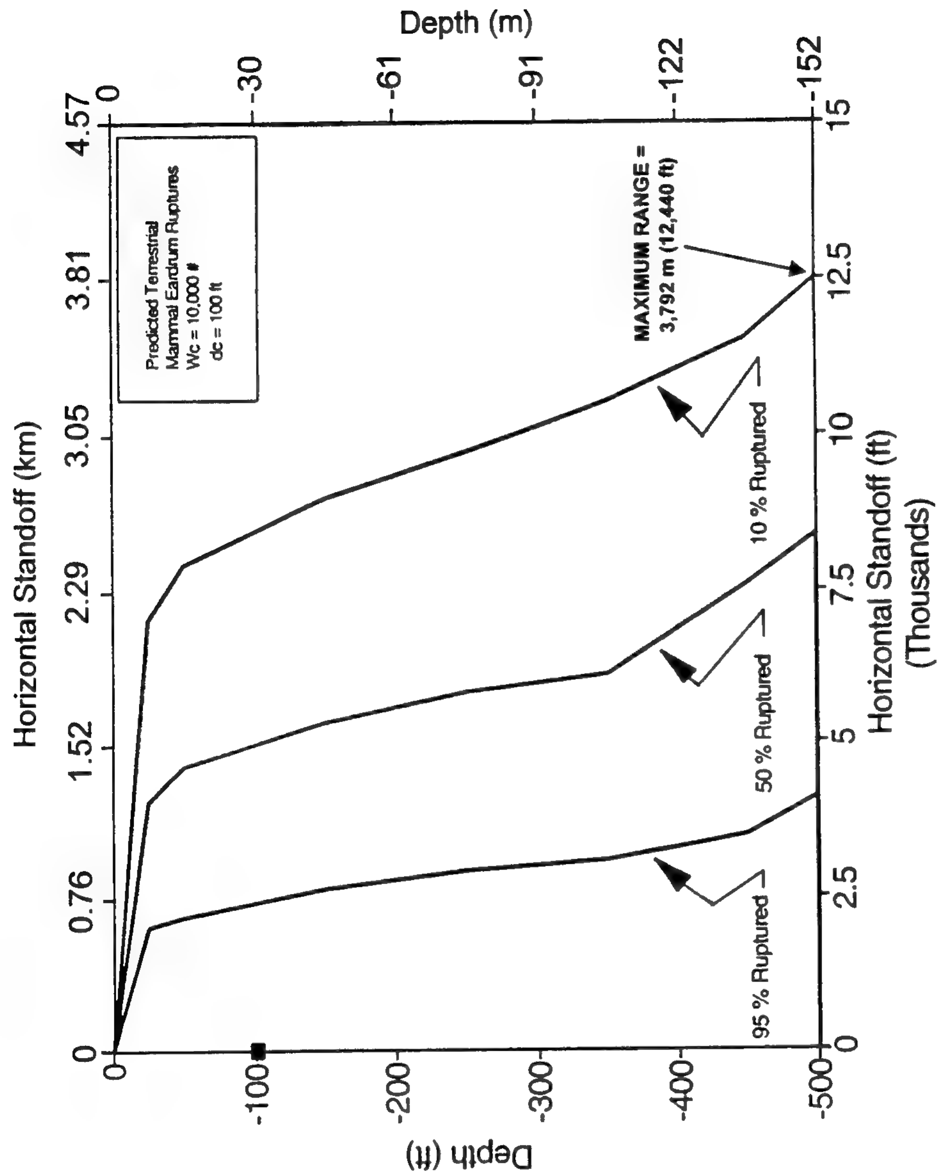


Figure 4-4. Eardrum rupture injury contours for a 4,536-kg (10,000-lb) charge (From: Appendix D).

Table 4-4 summarizes the mortality and injury calculations for the Mayport area. Estimated totals for five detonations are 1 mortality and 5 injuries. It is very unlikely that even one individual of any given species would be killed or injured by a single detonation. Species most likely to be affected at Mayport are pantropical spotted dolphin and Risso's dolphin.

The only endangered marine mammal species potentially killed or injured at Mayport is the sperm whale. The estimated numbers are 0.01 or less per detonation for both mortality and injury; totals for five detonations are 0.01 mortalities and 0.05 injuries. Therefore, it is highly unlikely that any sperm whales would be killed or injured by the five detonations. Sperm whales produce distinctive clicked vocalizations (Jefferson et al., 1993) and are very likely to be detected (if present) using the passive acoustic monitoring system described in Section 5.0 (Tyack, 1996). The other endangered marine mammals (blue, fin, humpback, sei, and northern right whales) are baleen whales which generally inhabit northern feeding grounds during the period proposed for shock testing (see Appendix B) and which were never observed off Mayport during the 1995 aerial census efforts. Therefore, it is assumed none would be killed or injured by the proposed action.

Table 4-5 summarizes the mortality and injury calculations for the Norfolk area. Estimated totals for five detonations are 8 mortalities and 38 injuries. Species that could have a total of more than one individual killed as a result of five detonations are pilot whale and Atlantic spotted dolphin. Species that could have more than one individual injured as a result of five detonations are pilot whale, Atlantic spotted dolphin, bottlenose dolphin, pantropical spotted dolphin, and common dolphin.

In contrast to Mayport, several endangered whale species could be affected at the Norfolk area. The highest numbers are for fin whale, which was the most abundant baleen whale at the area during 1995 aerial surveys. It is unlikely that a fin whale would be killed (0.12 individuals), but more likely that one would be injured (0.60 individuals). For the humpback, sei, and sperm whales, the mortality values per detonation are 0.01 individuals or fewer, indicating it is very unlikely that individuals of these species would be killed. Two other endangered species, the blue whale and the northern right whale, generally inhabit northern feeding grounds during the period proposed for shock testing and were never observed off Norfolk during the 1995 aerial census efforts; therefore, they are assumed to have no mortalities or injuries. In general, potential risk to endangered whale species would be lowest if testing occurred during July, August, or September; during 1995 aerial surveys, only one individual of an endangered species (fin whale) was seen during those months.

Both tables show the mitigation effectiveness for individual species and for total marine mammals. Overall mitigation effectiveness for mortality and injury would be about 93% for both Mayport and Norfolk.

Acoustic Discomfort

An underwater explosion produces pressure pulses that have the potential for damaging the hearing of marine mammals (Ketten, 1994). Depending on an animal's distance from the detonation point, it could experience a temporary or permanent shift in the threshold of hearing (the quietest sound that the animal can hear), which could affect

the animal's ability to hear calls, echolocation sounds, and other ambient sounds. Animals close to the detonation point could experience permanent threshold shift (PTS), which is permanent hearing loss. Animals at greater distances could experience temporary threshold shift (TTS). At still greater distances, animals could experience acoustic discomfort, which would be a momentary disturbance with no effect on hearing thresholds.

According to Richardson et al. (1995), the distances at which marine mammal auditory systems might be at risk for PTS from a single explosive pulse can be estimated based on extrapolations from human damage risk criteria. Based on the data presented by Richardson et al. (1995; p. 376), PTS might be expected to occur within distances of about 3.1 km (1.7 nmi) from the detonation point for a 4,536 kg (10,000 lb) charge. Ketten (1994) hypothesized a smaller PTS zone extending about 0.9 km (0.5 nmi) from the detonation point, within which >50% of animals would have some permanent hearing loss; and a PTS/TTS transitional zone extending from about 0.9 to 5 km (0.5 to 2.7 nmi) from the detonation point, within which most animals would have some temporary hearing loss but some permanent auditory damage would also be found. Based on these calculations and the fact that shock wave intensity decays exponentially with distance, it is reasonable to assume that PTS is unlikely to occur beyond the eardrum rupture range defined previously (3.79 km or 2.05 nmi). Therefore, PTS is not discussed further.

Harassment, as defined in the 1994 amendments to the Marine Mammal Protection Act of 1972, is "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild;" (Level A harassment) or "(ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" (Level B harassment). Level A harassment means injury, which has been discussed above. The NMFS has not defined a threshold for Level B harassment, but has cited TTS as an example (60 Federal Register at 28383, 31 May 1995). As explained below, there are currently insufficient data to develop a TTS criterion for marine mammals. Therefore, a criterion for "acoustic discomfort" has been used in this impact analysis. The number of marine mammals potentially experiencing acoustic discomfort is an overestimate of Level B harassment. Acoustic discomfort would be a momentary disturbance that would not cause TTS and would not be expected to cause disruption of behavioral patterns such as migration, breathing, nursing, breeding, feeding, or sheltering. In addition, because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would experience this momentary discomfort more than once.

To define the range (distance) of possible effects on marine mammal hearing, an interim criterion for acoustic discomfort was developed based on sound levels that would not cause TTS (Appendix E). The most meaningful criterion would be one based on measurements of TTS resulting from exposure of marine mammals to underwater noise. Although hearing thresholds for odontocetes and pinnipeds exposed to pure tones have been measured, there are no available TTS data for any marine mammals (Richardson et al., 1995). Therefore, other methods were used to develop a criterion for acoustic discomfort. Data obtained from humans immersed in water and exposed to brief pure tones were used, assisted by human in-air data, to construct an underwater hearing-safety limit for marine mammals. Evidence that indicates how safe this limit is has been provided in Appendix E. The acoustic discomfort criterion was then applied to define an

acoustic discomfort range for the proposed detonations. Site-specific hydrographic data from the Mayport and Norfolk areas were used to calculate the acoustic discomfort range (Appendix E).

Based on the analysis in Appendix E, the maximum range for acoustic discomfort at the Mayport and Norfolk areas is 11.11 km (6 nmi). Expected numbers of marine mammals within this radius were calculated using adjusted mean densities from Section 3.2.3. Because only individuals outside the 3.79 km (2.05 nmi) safety range would be affected, the "with mitigation" and "without mitigation" numbers would be the same.

It is considered impractical to attempt to mitigate for possible acoustic discomfort, which is a momentary disturbance. Increasing the safety range from 3.79 km (2.05 nmi) to 11.11 km (6 nmi) would increase the area by more than 850%, thus reducing the effectiveness of mitigation for mortality and injury.

Because of the larger area of the acoustic discomfort range, more individuals and more species could be affected. Therefore, species historically present at or near each area but not seen during 1995 aerial surveys were taken into account in these calculations. This includes, for example, species such as the dwarf and pygmy sperm whales (*Kogia* spp.) which appear frequently in stranding reports from the southeastern U.S. but are rarely seen at sea. Each species was assigned a value of 0.2 individuals per detonation, for a total of 1 individual per 5 detonations. This value is similar to the values calculated for the least abundant species observed during 1995 aerial surveys. The results were totalled and then rounded up to the nearest whole number.

Tables 4-4 and 4-5 summarize the results of the acoustic discomfort calculations for the Mayport and Norfolk areas. For a single detonation, approximately 109 individuals could be affected at Mayport and approximately 964 individuals could be affected at Norfolk. For five detonations, 570 animals could be affected at Mayport and 4,819 at Norfolk. The species most likely to be affected at Mayport are pantropical spotted dolphin, Risso's dolphin, and Atlantic spotted dolphin. The species most likely to be affected at Norfolk are pilot whale, Atlantic spotted dolphin, bottlenose dolphin, and pantropical spotted dolphin. Most species present at either area would have several individuals affected.

Behavioral Responses

Research on behavioral reactions of marine mammals to impulsive noise has been summarized by Richardson et al. (1995). Although some controlled experiments have been conducted, most of the available information is anecdotal, with no data on the sound levels at the source and the receiver. Behavioral responses to sounds produced by underwater explosions and airgun arrays can include avoidance, altered patterns of surfacing and respiration, and interruptions in calling. Richardson et al. (1995) concluded that "some baleen whales show no strong behavioral reaction to noise pulses from distant explosions. They also show considerable tolerance of similar noise pulses from nonexplosive seismic exploration. However, strong seismic pulses elicit active avoidance, suggesting that explosives may sometimes do so as well."

There is not as much information available on the behavioral responses of toothed whales and dolphins (Richardson et al., 1995). Avoidance and/or interruptions in calling have been documented in sperm whales at great distances from airgun arrays (Bowles et al., 1994; Mate et al., 1994). Small explosive charges have often been used, with mixed success, to influence movement of dolphins (e.g., "seal bombs" used during purse-seining for yellowfin tuna).

It is reasonable to conclude that sounds produced by each detonation during SEAWOLF shock testing could startle marine mammals or result in avoidance or other subtle behavioral changes at distances beyond the acoustic discomfort range discussed above. However, each detonation would be a single momentary disturbance. Because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would hear more than one detonation. Therefore, no lasting impact on movements, migration patterns, breathing, nursing, breeding, feeding, or other normal behaviors would be expected.

Indirect Impacts

An indirect way in which marine mammals could be affected is through death and injury to prey species. However, significant impacts are unlikely because (1) the Mayport and Norfolk areas are not known marine mammal feeding grounds, and (2) only a small area would be affected and prey populations would be rapidly replenished.

Toothed whales feed primarily upon mesopelagic and benthic fish. Sperm whales, pygmy sperm whales, and dwarf sperm whales prey primarily on squid; pygmy and dwarf sperm whales also feed on fish, octopus, and crustaceans. The main prey for pilot and beaked whales includes squid and fish (e.g., mackerel). Dolphins routinely consume squid and/or fish. Killer whales prey on a variety of marine organisms, including fish, sea turtles, seabirds, pinnipeds, and other marine mammals. Among the baleen whales, humpback whales feed primarily on euphausiids and small fish (e.g., mackerel, herring).

Pelagic fish and invertebrates within the cavitation region at the time of detonation are expected to be killed or injured. However, it is unlikely that prey availability would be altered for more than a few hours. Fish and invertebrate nekton (e.g., squid) from surrounding areas would quickly repopulate the small area affected. Plankton populations would be replenished through turbulent mixing with adjacent waters and population growth of each plankton species. Given that test site selection would be based on the low abundance of marine mammals, including both toothed and baleen whales, and given that the Mayport and Norfolk areas do not represent recognized feeding grounds for marine mammals, the potential for significant indirect effects is very low.

Summary

Potential direct impacts on marine mammals have been analyzed in detail in the preceding discussion. Possible direct impacts include mortality, injury, acoustic discomfort, and behavioral responses. Possible indirect impacts to marine mammals due to impacts on prey species have also been discussed above but are considered not significant.

Table 4-6 summarizes marine mammal calculations for the Mayport and Norfolk areas. Estimated totals for five detonations at Mayport are 1 mortality, 5 injuries, and 570 animals experiencing acoustic discomfort. Estimated totals for five detonations at the Norfolk area are 8 mortalities, 38 injuries, and 4,819 animals experiencing acoustic discomfort. The potential for mortality, injury, and acoustic discomfort is about eight times lower at Mayport than at Norfolk. Mitigation effectiveness for mortality and injury would be about the same at the two areas (93%).

At Mayport, it is very unlikely that any endangered marine mammals would be killed or injured. Sperm whales could be present, but in very low densities, and these animals are very likely to be detected by passive acoustic monitoring (see Section 5.0). Northern right whales and other endangered baleen whales are very unlikely to occur at the Mayport area during the time period proposed for shock testing (May through September). At Norfolk, the endangered fin whale is abundant enough to possibly have a mortality or injury. Endangered humpback, sei, and sperm whales could also be present at Norfolk, but in very low densities. Other endangered species are very unlikely to occur at the Norfolk area during the time period proposed for shock testing (April through September).

The numbers presented above are based on conservative assumptions which overestimate impacts at both Mayport and Norfolk. As described in Section 5.0, the Navy proposes to select a specific test site with few, if any, marine mammals present. The proposed mitigation methods for SEAWOLF shock testing were used successfully during

Table 4-6. Summary and comparison of Mayport and Norfolk areas with respect to marine mammal related impacts and mitigation effectiveness. Data are from the last row of Tables 4-4 and 4-5.

Category	Description	Mayport	Norfolk
Mortality	Number of individuals potentially killed from 5 detonations	1	8
Injury	Number of individuals potentially injured from 5 detonations	5	38
Acoustic discomfort	Number of individuals potentially experiencing acoustic discomfort from 5 detonations	570	4,819
Mitigation effectiveness for mortality and injury	Percentage of individuals within safety range that would be detected by combination of aerial, surface, and passive acoustic monitoring	93%	93%

the shock trial of the USS JOHN PAUL JONES, resulting in no deaths or injuries to marine mammals (Naval Air Warfare Center, 1994). Detection of even one marine mammal within the safety range would result in postponement of detonation; therefore, the presence of marine mammals would most likely result in testing delays rather than impacts on these animals.

4.2.2.4 Sea Turtles

Two main types of potential direct impacts on sea turtles are discussed here. First, animals may be killed or injured if they are present near the detonation point and not detected during pre-test monitoring. Second, animals at greater distances may be disturbed by the physical and acoustic signatures of the explosions. Possible indirect impacts to sea turtles are also discussed.

In addition to these main effects, there are several minor issues that do not require detailed analysis. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3). Minor increases in vessel and air traffic are not a major concern from the standpoint of sea turtle harassment because of built-in mitigation measures (use of shipboard observers; limited transit speed; flights at approved altitudes).

Because listed (endangered or threatened) species of sea turtles may occur at the Mayport or Norfolk areas, formal consultation with the NMFS is required under the Endangered Species Act. This DEIS includes a Biological Assessment (Appendix G) which will be submitted to the NMFS. The NMFS will issue a Biological Opinion taking into account the cumulative impacts of all activities potentially affecting listed marine mammal and turtle populations. The proposed action cannot occur unless the Biological Opinion concludes that shock testing is not likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat.

The proposed action includes mitigation that would minimize risk to sea turtles (see Section 5.0). The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If small turtles were found associated with floating *Sargassum* within the safety range, they would be removed and temporarily held in a sun-protected area on the deck of the MART vessel until after the detonation (see Section 5.0). If post-detonation monitoring showed that marine mammals or sea turtles were killed or injured as a result of a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

Mitigation measures also include a schedule shift to avoid high turtle densities in April at Mayport. Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September 1997. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly

between April and September 1995, as explained in Section 3.2.4. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

Mortality and Injury

Field observations have shown that sea turtles can be killed or injured by underwater explosions (O'Keeffe and Young, 1984; Klima et al., 1988). Effects are likely to be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (see Figure 4-1). This is a region of near total physical trauma within which no animals would be expected to survive. Beyond the bulk cavitation region, animals could still receive serious or minor injuries depending on distance from the detonation point.

The concept of a "safety range" has been discussed above under Marine Mammals. The same safety range of 3.79 km (2.05 nmi) would be used for both sea turtles and marine mammals. Detonation would not occur until there are no sea turtles or marine mammals detected within the safety range.

Although the safety range was calculated based on estimated maximum ranges for marine mammal mortality and injury (Appendix D), it is more than sufficient to protect sea turtles as well. The safety range is nearly three times greater than the non-injury range of 1.31 km (0.71 nmi) predicted using the O'Keeffe and Young (1984) equation for sea turtles. It is similar to the predicted safe range of 3.68 km (2 nmi) calculated using an equation developed by Young (1991).

With the safety range in place, sea turtles may be killed or injured only if they are not detected during pre-test monitoring. To estimate how many sea turtles could be killed or injured, the same methods and assumptions were used as described above under Marine Mammals. There is comparatively little experimental or theoretical data upon which to base mortality and injury ranges for sea turtles (O'Keeffe and Young, 1984; Young, 1991). Therefore, the corresponding ranges for marine mammals were used. These ranges were developed based on experiments with mammals (see Appendix D), but it is reasonable to assume that sea turtle lungs and other gas-containing organs would be similarly affected by shock waves (O'Keeffe and Young, 1984). The mortality range of 1,524 m (5,000 ft) and the injury range of 3,792 m (12,440 ft) exceed the distances at which sea turtle mortality and injury would be predicted based on the few observations cited by O'Keeffe and Young (1984) and Klima et al. (1988).

Tables 4-7 and 4-8 summarize mortality and injury calculations for sea turtles at the Mayport and Norfolk areas. For five detonations "with mitigation," the estimated mortality is 6 for Mayport and 7 for Norfolk. Predicted numbers of injured turtles for five detonations are 30 at Mayport and 32 at Norfolk. Loggerheads make up over 90% of the population at both areas and are the species most likely to be killed or injured.

Both of the sea turtle species potentially killed or injured at Mayport or Norfolk are listed species (endangered or threatened). Loggerheads are threatened, whereas

Table 4-7. Estimates of potential sea turtle mortality, injury, and acoustic discomfort from shock testing at the Mayport area, with and without mitigation. Shock testing would only be conducted "with mitigation," including no testing in April at Mayport. Numbers are given to two decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Mayport during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
Loggerhead sea turtle (T)	1.11	5.74	51.92	0.08	1.02	5.27	51.92	5.08	26.36	259.62
Leatherback sea turtle (E)	0.08	0.43	3.88	0.10	0.07	0.39	3.88	0.37	1.94	19.37
Unidentified sea turtle	0.04	0.23	2.11	0.09	0.04	0.21	2.11	0.21	1.06	10.57
* Green sea turtle (T)	0	0	0.20	NA	0	0	0.20	0	0	1
* Hawksbill sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Kemp's ridley sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1
TOTAL	1.23	6.40	58.51	0.08[d]	1.13	5.87	58.51	**6** (5.66)	**30** (29.36)	**293** (292.56)

(E) = endangered species. (T) = threatened species. NA = not applicable. * = species historically present in the region but not seen at Mayport area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.4) for May through September at Mayport, scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).
b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial and surface monitoring (see Appendix B).
c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).
d Overall mitigation effectiveness was calculated as 1 minus (total with mitigation/total without mitigation).

Table 4-8. Estimates of potential sea turtle mortality, injury, and acoustic discomfort from shock testing at the Norfolk area, with and without mitigation. Shock testing would only be conducted "with mitigation." Numbers are given to two decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Norfolk during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
Loggerhead sea turtle (T)	1.21	6.30	56.99	0.08	1.11	5.78	56.99	5.57	28.92	284.93
Leatherback sea turtle (E)	0.02	0.12	1.08	0.10	0.02	0.11	1.08	0.11	0.54	5.40
Unidentified sea turtle	0.08	0.39	3.53	0.09	0.07	0.36	3.53	0.34	1.78	17.66
* Green sea turtle (T)	0	0	0.20	NA	0	0	0.20	0	0	1
* Hawksbill sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Kemp's ridley sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1
TOTAL	1.31	6.81	62.20	0.08[d]	1.20	6.25	62.20	**7** (6.02)	**32** (31.24)	**311** (310.99)

(E) = endangered species. (T) = threatened species. NA = not applicable. * = species historically present in the region but not seen at the Norfolk area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.4) for April through September at Norfolk scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).
b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial and surface monitoring (see Appendix B).
c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).
d Overall mitigation effectiveness was calculated as 1 minus (total with mitigation/total without mitigation).

leatherbacks are endangered. The three other sea turtle species (green, hawksbill, and Kemp's ridley) are also endangered or threatened, but these are primarily inshore species which were not seen at either area during 1995 aerial surveys. Therefore, no mortalities or injuries of these species are expected.

Average mitigation effectiveness for mortality and injury is about 8% for both Mayport and Norfolk. Mitigation is not very effective for sea turtles because they are small, stay submerged for extended periods, do not make visual displays (like dolphins leaping or whales blowing) and do not make sounds. Mitigation effectiveness for juvenile turtles is assumed to be equal to that for adult turtles; although juveniles are smaller, they are often associated with *Sargassum* mats, which would be spotted by aerial observers and investigated by scientists from the MART vessel (see Section 5.0).

Acoustic Discomfort

An underwater explosion produces pressure pulses that have the potential for damaging the hearing of sea turtles. Results of such an exposure could lead to TTS, which is a temporary increase in the threshold of hearing (the quietest sound that the animal can hear). Animals closer to the detonation point (probably within the range of eardrum rupture) could experience permanent hearing loss.

In Appendix E, a conservative range for marine mammal acoustic discomfort at the Mayport and Norfolk areas has been defined as 11.11 km (6 nmi). Assuming that sea turtle sensitivity is equal to or less than that of marine mammals, the same range can be used to estimate the potential for sea turtle acoustic discomfort. To estimate how many sea turtles could experience acoustic discomfort, the same methods and assumptions were used as described above under Marine Mammals. Species historically present at or near each area but not seen during 1995 aerial surveys (i.e., green, hawksbill, and Kemp's ridley turtles) were taken into account in the calculations. Each species was assigned a value of 0.2 individuals per detonation, for a total of 1 individual per 5 detonations.

Tables 4-7 and 4-8 summarize the results of the acoustic discomfort calculations for sea turtles at the Mayport and Norfolk areas, based on a single detonation. For five detonations "with mitigation," 293 animals could be affected at Mayport and 311 at Norfolk. As noted above, loggerheads make up over 90% of the population at both areas and are the species most likely to be affected.

Behavioral Responses

Behavioral responses could occur at distances beyond the acoustic discomfort range discussed above. Sea turtles are thought to be capable of hearing low frequency sounds. Ridgway et al. (1969) suggested that optimal sea turtle hearing occurs in the range of 200 to 700 Hz, with useful sensitivity extending from approximately 60 to 1,000 Hz. Sensitivity falls off significantly below 200 Hz. Sea turtles may hear the brief (<50 msec) acoustic signal created by the proposed underwater detonations. This could result in behavioral effects, such as swimming toward the surface, abrupt movements, slight retractions of the head, and limb extension during swimming (Lenhardt et al., 1983; Lenhardt, 1994). However, each detonation would be a single momentary disturbance.

Because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would hear more than one detonation. Therefore, no lasting impact on movements, migration patterns, breathing, feeding, or other normal behaviors would be expected.

Indirect Impacts

Two indirect ways in which sea turtles could be affected are through (1) death and injury to prey species and (2) destruction of juvenile habitat (*Sargassum* rafts). Both impacts are unlikely to be significant at either the Mayport or Norfolk area.

Adult loggerheads feed primarily on benthic molluscs and crustaceans. Loggerheads present at the Mayport and Norfolk areas are presumed not to feed there due to the water depth. Leatherback turtles are pelagic feeders, preferring coelenterates (jellyfish). Some jellyfish are likely to be killed during the blast, but it is unlikely that prey availability would be reduced. Coelenterates from surrounding areas would quickly repopulate the small area affected. Given that test site selection and scheduling would be based on the low abundance of sea turtles, and given that the Mayport and Norfolk areas do not represent recognized feeding grounds for loggerhead or leatherback sea turtles, the potential for significant indirect effects is very low.

As noted above, *Sargassum* rafts which may serve as habitat for loggerhead juveniles are easily detected by aerial observers. Rafts detected in the safety range would be investigated by the Marine Animal Recovery Team (MART) (see Section 5.0). If any juvenile turtles are found associated with a *Sargassum* raft, the test would be postponed. Therefore, no impacts on juvenile turtle habitat are expected.

Summary

Potential direct impacts on sea turtles have been analyzed in detail in the preceding discussion. Possible direct impacts include mortality, injury, and acoustic discomfort. Possible indirect impacts to sea turtles due to impacts on prey species have also been discussed above but are considered not significant.

Table 4-9 summarizes sea turtle calculations for the Mayport and Norfolk areas. Estimated totals for five detonations at Mayport are 6 mortalities, 30 injuries, and 293 animals experiencing acoustic discomfort. Estimated totals for five detonations at Norfolk are 7 mortalities, 32 injuries, and 311 animals experiencing acoustic discomfort. Therefore, the potential for mortality, injury, and acoustic discomfort is about the same at the two areas. Mitigation effectiveness would also be the same at either area (about 8%). Loggerheads make up over 90% of the population at both areas and are the species most likely to be affected.

The numbers presented above are based on conservative assumptions which overestimate impacts at both Mayport and Norfolk. As described in Section 5.0, the Navy proposes to select a specific test site with few, if any, sea turtles present. The proposed mitigation methods for SEAWOLF shock testing were used successfully during the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994). Detection of even one sea turtle within the safety range would result in postponement of detonation;

Table 4-9. Summary and comparison of Mayport and Norfolk areas with respect to sea turtle related impacts and mitigation effectiveness. Data are from the last row of Tables 4-7 and 4-8.

Category	Description	Mayport	Norfolk
Mortality	Number of individuals potentially killed from 5 detonations	6	7
Injury	Number of individuals potentially injured from 5 detonations	30	32
Acoustic discomfort	Number of individuals potentially experiencing acoustic discomfort from 5 detonations	293	311
Mitigation effectiveness for mortality and injury	Percentage of individuals present within safety range that would be detected by combination of aerial and surface observers	8%	8%

therefore, the presence of sea turtles would most likely result in testing delays rather than impacts on these animals.

4.2.2.5 Benthos

Two types of potential impacts on benthic organisms are (1) direct effects of the shock wave on organisms and their seafloor habitat; and (2) indirect effects of debris deposited on the bottom. In either case, no significant impact to benthic communities is expected. This conclusion applies equally to the Mayport and Norfolk areas.

Benthic organisms are unlikely to be killed or injured by the detonations. Most of the mortalities during underwater explosions occur in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation." Benthic organisms, in contrast, would experience only the direct, positive pressure wave and reflections from the bottom. Bottom features that develop a dense epifauna, such as artificial reefs, hard bottom areas, and shipwrecks, have been avoided through environmental mapping and establishment of buffer zones (see Section 2.2.2.2).

Experimental studies have shown that benthic invertebrates, including crabs, lobsters, and bivalves are very resistant to underwater explosions (Aplin, 1947; Chesapeake Biological Laboratory, 1948; Linton et al., 1985). Based on these studies, Young (1991) developed equations which predict a safety range of 22 m (73 ft) for benthic organisms exposed to a 4,536 kg (10,000 lb) charge. That is, organisms more than this distance from the detonation point would not be killed. Because the blast would be 122 m (400 ft) above the bottom, no benthic organisms are likely to be killed or injured.

Demersal (bottom dwelling) fish are unlikely to be killed or injured by the detonations. The distances listed in Table 4-3 apply to fish near the surface, where the reflected shock wave produces a region of negative pressure. Fish in deeper water or on the bottom could survive much closer to the blast. These fish would experience only the direct, positive pressure wave and reflections from the bottom. Under these conditions, there would not be much difference in survival between swimbladder and non-swimbladder species. Bottom features that attract large numbers of demersal fish, such as artificial reefs, hard bottom areas, and shipwrecks, have been avoided through environmental mapping and establishment of buffer zones (see Section 2.2.2.2).

Golden tilefish is a demersal species present at both the Mayport and Norfolk areas. A calculation of tilefish mortality contours for a 4,536 kg (10,000 lb) charge detonated at a depth of 61 m (200 ft) was made for a previous environmental assessment (Department of the Navy, 1981). For an explosion at a depth of 30 m (100 ft), the contours would move upward by 17 m (55 ft) (Young, 1995b). Only the 10% mortality contour approaches the bottom. Therefore, few if any tilefish or other bottom dwelling fish would be killed by the detonations.

Similarly, the shock wave is not expected to affect the benthic habitat. Calculations based on the size and depth of the explosive charge and the total water depth indicate there would be no cratering of the seafloor (see Section 4.2.1.1).

The seafloor at both the Mayport and Norfolk areas is predominantly sand bottom. Fragments of steel charge casings that settle to the bottom would provide hard substrate for epibiota and would attract fish (Marine Resources Research Institute, 1984). The largest possible fragment from the explosion is the top plate and crossbar, which together weigh 204 kg (450 lb).

4.2.2.6 Seabirds

The Navy would make every effort to prevent and/or minimize harm to seabirds which may be in the vicinity of the test site during detonation. As part of the mitigation plan, the Navy would postpone detonation if flocks of seabirds were present within the safety range (see Section 5.0). This would avoid any large mortality of seabirds. Monitoring following detonation of two 4,536 kg (10,000 lb) charges for the shock trial of the USS JOHN PAUL JONES in 1994 showed there were no deaths or injuries of seabirds (Naval Air Warfare Center, 1994).

It is possible that a few seabirds on the water surface or in the air immediately above the detonation point could be killed or stunned by the plume of water ejected into the air. This could happen if birds were attracted to surface floats at the detonation point, as observed by Stemp (1985). The radius of the plume is estimated to be 165 to 195 m (540 to 640 ft) (Young, 1995b).

At greater distances, seabirds resting or feeding at the surface could also be killed or injured by the shock wave. Most of the seabirds that could occur at either Mayport or Norfolk during April through September are surface or near-surface feeders. Safe ranges for these birds can be estimated using mortality and injury criteria developed by Yelverton et al. (1973). The calculations show that no deaths or injuries would be expected beyond a distance of 457 m (1,500 ft) (Young, 1995b). This is approximately

the same as the maximum horizontal range of the bulk cavitation region shown in Figure 4-1. It is unlikely that more than a few seabirds would be affected.

Each detonation would release chemical products into the atmosphere. As described in Section 4.2.1.2, these products would disperse rapidly and would not pose a health threat to marine life, including seabirds.

The USFWS has concluded that there are no endangered or threatened bird species or critical habitat that would be adversely affected by the proposed action (see Appendix C).

4.2.3 Socioeconomic Environment

4.2.3.1 Commercial and Recreational Fisheries

The explosion shock wave may kill or injure individual fish that are targets of commercial and recreational fisheries. However, a large fish kill would not be expected during SEAWOLF shock testing because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0). Due to the large populations and wide geographic distribution of the species present near Mayport and Norfolk and the limited area affected, the explosions would not be expected to have a significant impact on fishery stocks.

Effects of explosions on fish have been discussed previously in Section 4.2.2.2. Small fish with swimbladders are the ones most likely to be killed or injured if present in surface waters within about 1,400 m (4,600 ft) of the detonation point. This category includes species such as dwarf herring, round scad, Atlantic menhaden, and chub mackerel. Some of these are commercially important species, although they are not fished within the Mayport or Norfolk areas.

The main targets of commercial and recreational fishing at both the Mayport and Norfolk areas are large oceanic pelagic species such as billfish, dolphinfish, tunas, wahoo, and sharks (see Table 3-3). Because sharks do not have a swimbladder, they are unlikely to be affected unless they are very close to the detonation point (within about 22 m or 73 ft). The other large species all have swimbladders and may be affected within a radius of about 762 m (2,500 ft) (see Section 4.2.2.2). Most of the oceanic pelagic fish are non-schooling, and large fish kills of these species are therefore unlikely. Schooling species such as dolphinfish, tunas, and (occasionally) wahoo are also unlikely to have significant numbers killed because detonation would be postponed if large schools were present within 1.85 km (1 nmi) of the detonation point.

Demersal (bottom dwelling) fish and invertebrates are unlikely to be killed or injured by the detonations, as explained in Section 4.2.2.5. Demersal fishery species are golden tilefish at both Mayport and Norfolk and summer flounder, black seabass, butterfish, hake, and squid at Norfolk only. Due to the water depth (152 m or 500 ft), the shock wave is not expected to affect these species or their habitat. Previous calculations of tilefish mortality contours for a 4,536 kg (10,000 lb) charge indicate that few if any tilefish or other bottom dwelling fish would be affected (Department of the Navy, 1981; see Section 4.2.2.5). No sediment resuspension or cratering of the seafloor is expected (see Section 4.2.1.1).

Fishing vessels would be excluded from the test site for about 18 hours during each shock test. Types of fishing most likely to be affected are surface and bottom longlining and trolling (see Table 3-3). Demersal trawling occurs only at the Norfolk area, and primarily during winter months, so shock testing is unlikely to interrupt this activity. Bottom longlining for golden tilefish occurs off both Mayport and Norfolk, but most tilefishing off Norfolk occurs from Norfolk Canyon north, an area which is excluded from testing. Surface longlining by commercial fishers and trolling by recreational anglers occur at both areas. Due to the short duration of each shock test and the advance warning provided through *Notices to Airmen and Mariners*, the temporary interruption is not expected to significantly affect commercial or recreational fisheries.

4.2.3.2 Ship Traffic

An exclusion zone of 9 km (5 nmi) radius would be established around the test site to exclude all non-test ship, submarine, and aircraft traffic. Any traffic within an 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the site. *Notices to Airmen and Mariners* would be published in advance of each test. Traffic would be excluded from the site for a period of about 18 hours for each detonation.

Both the Mayport and Norfolk areas are well offshore, and neither is near shipping lanes. The Navy selected these areas as having a low volume of ship traffic. No significant impacts on ship traffic are expected.

4.2.3.3 Other Socioeconomic Issues

There are no ocean disposal sites within 18.5 km (10 nmi) of either the Mayport or Norfolk area. Since this is the radius within which ships would be warned to alter course, testing would not conflict with use of any ocean disposal site. There are no communications cables at the Norfolk area, and the one cable identified off Mayport is no longer in use (Department of the Navy, 1995a). There would be no impact to international telecommunications should the cable be damaged (Wargo, 1994).

5.0 MITIGATION AND MONITORING

The proposed action includes the following mitigation measures: (1) a marine mammal and sea turtle mitigation plan to minimize the risk of impacts to marine life; (2) a schedule shift at Mayport to avoid high densities of sea turtles; (3) environmental buffer zones to avoid impacts to certain environmental features; (4) a vessel exclusion zone for operational security; and (5) measures to deal with unexploded ordnance in the unlikely event of a misfire. Because the marine mammal and sea turtle mitigation plan is the most detailed, the other measures are discussed first.

5.1 SCHEDULE SHIFT TO AVOID HIGH TURTLE DENSITIES AT MAYPORT

Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September 1997. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995, as explained in Section 3.2.4. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

5.2 ENVIRONMENTAL BUFFER ZONES

At both the Mayport and Norfolk areas, possible test sites were defined to meet operational depth restrictions; this being any point along the 152 m (500 ft) depth contour within 185 km (100 nmi) of a naval station support facility and a submarine repair facility. Environmental features near each area were mapped, including marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, and critical habitat for endangered or threatened species (Department of the Navy, 1995a). Buffer zones were developed to avoid impacts to these areas and associated biota. Portions of the 152 m (500 ft) depth contour were excluded as described in Section 2.2.2.2. At the Mayport area there are no marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, or critical habitat areas. Therefore, all points along the 152 m (500 ft) depth contour are considered potential shock testing sites. At the Norfolk area, the portion of the 152 m (500 ft) depth contour passing through the proposed Norfolk Canyon Marine Sanctuary, along with a 4.6 km (2.5 nmi) buffer on either side, was excluded. The entire area north of the proposed sanctuary was eliminated due to the presence of several shipwrecks within a distance of 1.85 km (1 nmi). All remaining points along the 152 m (500 ft) depth contour are considered potential shock testing sites.

5.3 VESSEL EXCLUSION ZONE

An exclusion zone of 9.3 km (5 nmi) radius would be established around the detonation point to exclude all non-test ship, submarine, and aircraft traffic. Any traffic within an 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the site. *Notices to Airmen and Mariners* would be published in advance of each

test. An immediate HOLD on the test would be ordered if any unauthorized craft entered the exclusion zone and could not be contacted. The HOLD would continue until the exclusion zone was clear of unauthorized vessels. The size of the exclusion zone is necessary for operational security and to allow large vessels sufficient time to change course.

5.4 UNEXPLODED ORDNANCE

The probability of a charge not detonating during a test is remote. Should a charge fail to explode, the Navy would attempt to identify the problem and detonate the charge (with all marine mammal and sea turtle mitigation measures in place as described below). If these attempts failed, the Navy would recover the explosive and disarm it. Only in case of an extreme emergency or to safeguard human life would the Navy dispose of the charge at sea. The possibility of disposing the explosive charge at sea is very remote. However, if disposal at sea was necessary, the charge would be disposed in a manner that would not pose a hazard to the public.

5.5 MARINE MAMMAL AND SEA TURTLE MITIGATION PLAN

A detailed marine mammal and sea turtle mitigation plan has been developed to reduce or eliminate the effects of shock testing on marine life. The plan includes the same type of mitigation and monitoring efforts that were used successfully during the shock trial of the USS JOHN PAUL JONES in 1994 off the coast of southern California where observed marine mammal population densities are about 3 times greater than at the Norfolk area and about 25 times higher than at the Mayport area (Department of the Navy, 1993). Those shock trial operations included two 4,536 kg (10,000 lb) detonations and resulted in no deaths or injuries of marine mammals (Naval Air Warfare Center, 1994).

Potential areas for SEAWOLF shock testing have been evaluated in Section 2 (Alternatives) based on the Navy's operational requirements. The analysis showed that only the Mayport and Norfolk areas meet all of the Navy's operational requirements and that the two areas are rated as nearly equal. Portions of the Norfolk area were excluded based on environmental considerations (proposed Norfolk Canyon National Marine Sanctuary and shipwrecks) (see Section 5.2). The schedule for testing at Mayport was shifted to avoid high turtle densities (see Section 5.1). Finally, impact analysis in Section 4 (Environmental Consequences) was used to identify a preferred alternative area (Mayport) based on the lower density of marine mammals.

The mitigation plan would build upon these previous efforts to avoid or further reduce potential environmental impacts. It would select one primary and two secondary test sites where marine mammal and turtle abundances are the lowest, based on the results of aerial surveys to be conducted immediately prior to the first detonation. This would ensure that the final test site selected for shock testing poses the least risk to the marine environment. Pre-detonation monitoring would be conducted prior to each detonation to ensure that the test site is free of marine mammals, turtles, large schools of fish, and flocks of seabirds. Finally, post-detonation monitoring would be conducted to determine the effectiveness of the mitigation efforts, by using a Marine Animal Recovery Team (MART) and aerial observers to monitor the test site and surrounding waters for injured or dead animals after each detonation.

5.5.1 Terminology

The concept of a ***safety range***, as presented in Section 4.2.2.3, is integral to the mitigation plan. Establishment of a 3.8 km (2.05 nmi) safety range around the detonation point has taken into consideration the estimated ranges for various levels of injury and/or mortality associated with detonation of a 4,536 kg (10,000 lb) explosive. Based on analyses presented in Appendix D, the maximum distance for the remote possibility of auditory system injury (i.e., eardrum rupture) to a marine mammal is 3.8 km (2.05 nmi) from the detonation point.

For mitigation monitoring purposes, a 1.8 km (0.95 nmi) ***buffer zone*** has also been added to the 3.8 km (2.05 nmi) safety range to accommodate the possible movement of animals towards the safety range. Specifically, the area encompassed within a 5.6 km (3 nmi) radius from the detonation point would be monitored in an effort to detect any marine mammals or turtles approaching the 3.8 km (2.05 nmi) safety range, as detailed below.

In the following sections, the term ***survey*** is used to refer to site selection activities, whereas ***monitoring*** refers to pre-detonation site clearance and post-detonation activities to locate and identify marine mammals or turtles.

5.5.2 Weather Limitations

Weather which supports the ability to sight even small marine life (e.g., sea turtles) is essential for mitigation measures to be effective. Winds, visibility, and the surface conditions of the ocean are the most critical factors affecting mitigation operations for the SEAWOLF shock test. High winds typically promote increases in wave height and "white cap" conditions, both of which limit an observer's ability to locate surfacing marine mammals and to differentiate between surfacing marine mammals and white caps. Based on the Navy's experience during the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994), weather conditions begin to adversely impact mitigation effectiveness in a sea state of Beaufort 5 (i.e., wind velocity 17-21 kt). Similarly, the results of cetacean census efforts off the California coast have also supported the effective conduct of surveys in weather conditions up to and including Beaufort 4; however, sighting rates are appreciably different in a comparison of Beaufort 0 to 2 and rough Beaufort 3 to 4 conditions (Barlow, 1995; Carretta et al., 1995; Forney et al., 1995). As a result, SEAWOLF shock testing would not be conducted in a sea state exceeding Beaufort 4 (i.e., wind velocity >16 kt). Visibility is also a critical factor, not only for observation capabilities but also for safety-of-flight issues. A minimum ceiling of 305 m (1,000 ft) and 1.85 km (1 nmi) visibility must be available to support mitigation and safety-of-flight concerns.

The aerial surveys conducted within the Mayport and Norfolk areas during the months of April through September 1995 were completed in a sea state of Beaufort 3 (i.e., wind velocity 7-10 kt) or less. These conditions ensured acceptable sighting conditions for the survey team which included two observers and a data logger. In contrast, the full mitigation team would consist of three observers in each aircraft, six or seven shipboard observers (four with high powered binoculars), and the Marine Mammal Acoustic Tracking System (MMATS) team. This complement of trained marine mammal

observers would provide five times the visual detection capability used during the 1995 aerial surveys. The increased number of observers would ensure effective mitigation during the shock test in a sea state of Beaufort 4 (i.e., wind velocity 11-16 kt).

5.5.3 Mitigation Components/Teams

The mitigation plan includes three components: (1) aerial surveys/monitoring; (2) shipboard monitoring from the operations vessel and the Marine Animal Recovery Team (MART) vessel; and (3) passive acoustic monitoring using the Marine Mammal Acoustic Tracking System (MMATS). Aerial and shipboard monitoring teams would identify and locate animals on the surface, whereas the acoustic monitoring team would detect and locate calls from submerged animals. The lines of communication between the various monitoring teams are outlined in **Figure 5-1** and discussed in the following section.

5.5.3.1 Aerial Survey/Monitoring Team

The aerial team would include one aircraft with three marine biologists aboard. Each biologist would be experienced in marine mammal surveying and would be familiar with species that may occur in the area. A backup aircraft with additional biologists would be available to support the shock test. The backup aircraft would relieve the primary aircraft for post-detonation monitoring. In consideration of safety-of-flight issues, only one aircraft would be allowed in the airspace over the test site at any one time (Naval Air Warfare Center, 1994). Each aircraft would have a data recorder who would be responsible for relaying the location, species, and number of animals sighted by aircraft personnel to the Lead Scientist onboard the operations vessel. The Lead Scientist would be responsible for recording all sightings within the test site and relaying this information to the Shock Test Director and the Officer in Tactical Command (OTC). The aerial monitoring team would also identify to the MART vessel any large accumulations of *Sargassum* that should be investigated for the presence of juvenile sea turtles.

Standard line transect aerial surveying methods, as developed by the NMFS (Blaylock, 1994; Hoggard, 1994; Mullin, 1994), would be used for all mitigation aerial surveys and monitoring. All aerial surveys and aerial monitoring would be conducted along transects spaced 1.85 km (1 nmi) apart and flown at an altitude of 198 m (650 ft) and a speed of 110 kt. Although the 1995 aerial surveys (Department of the Navy, 1995b) off Norfolk and Mayport were flown at an altitude of 229 m (750 ft), an altitude of 198 m (650 ft) was chosen for the mitigation aerial surveys and monitoring to increase visual detection of sea turtles. Observers on both sides of the aircraft would scan a swath of sea surface which would be limited only by the effective angle of view from the aircraft's viewing ports or windows, and sea state. Based on the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994) and prior survey efforts off Mayport and Norfolk, aerial observers are expected to have good to excellent sighting capability to 0.9 km (0.5 nmi) on either side of the aircraft within the weather limitations noted previously. Observed marine mammals and turtles would be identified to species or the lowest possible taxonomic level, and their relative positions recorded. Detonations would only occur no earlier than three hours after sunrise and no later than three hours prior to sunset to ensure adequate daylight for pre- and post-detonation monitoring.

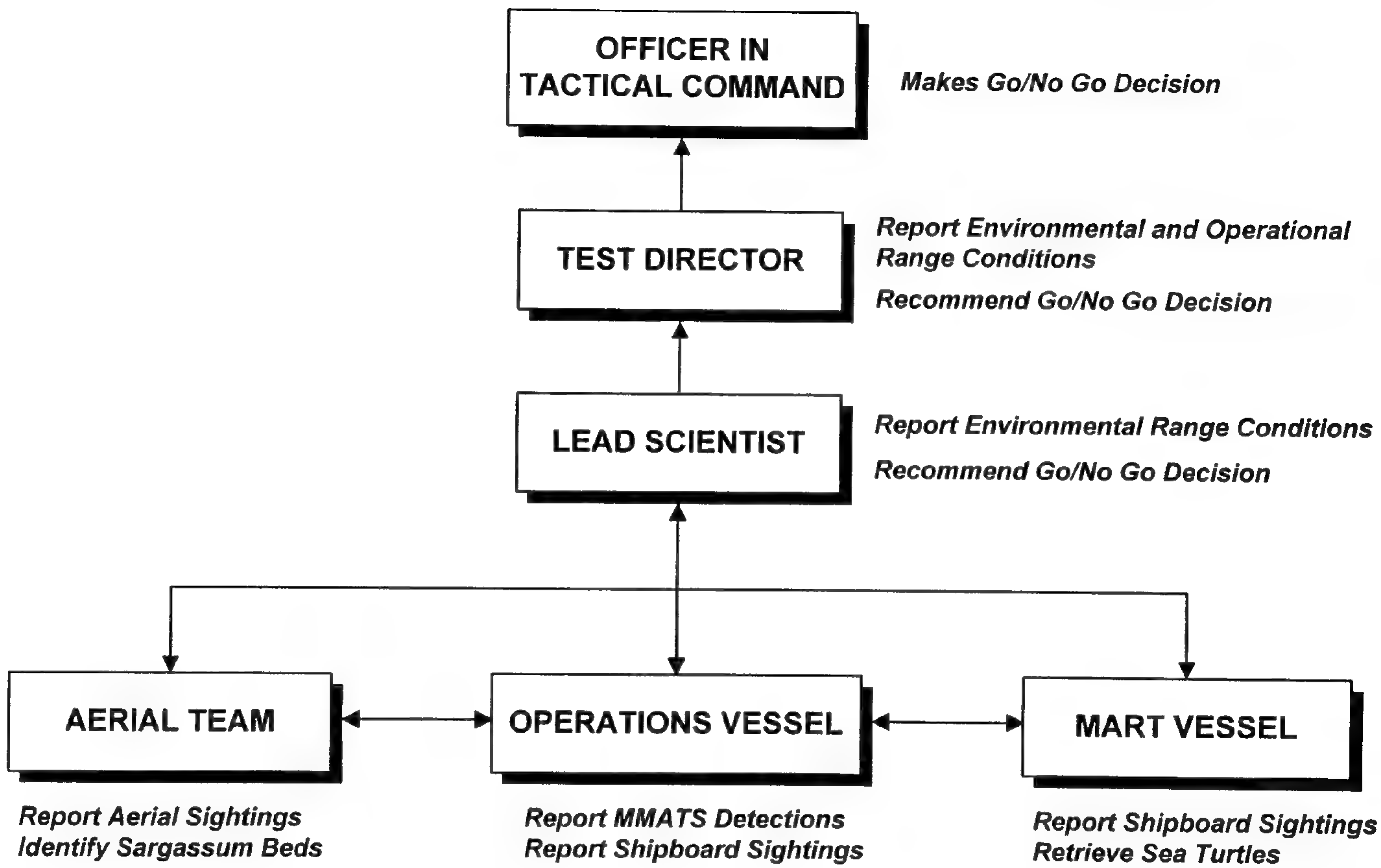


Figure 5-1. Lines of communication between the aerial monitoring team, operations vessel, and MART vessel.

5.5.3.2 *Shipboard Monitoring Teams*

Shipboard monitoring would be staged from surface craft participating in the shock test, including the operations vessel and the MART vessel. Each vessel would be outfitted with two sets of 25X binoculars. The operations vessel would accommodate three marine biologists experienced in shipboard surveys and who are familiar with the marine life of the area. Two biologists would monitor the test site with the vessel-mounted (i.e., installed on the bridge wing or deckhouse of the operations vessel) 25X binoculars or hand-held binoculars. The 25X binoculars would allow the biologists to sight surfacing mammals from as far as 11.1 km (6 nmi). The third biologist would rotate stations with the other two biologists to allow each an opportunity to rest their eyes. The positioning of the shipboard monitoring teams would allow 360° overlapping coverage. Each biologist would report all sightings to the Lead Scientist located on the operations vessel. As with all aerial monitoring team sightings, the Lead Scientist would be responsible for recording all sightings made by the shipboard monitoring team. Each sighting would be recorded and plotted (i.e., latitude, longitude) relative to the point of detonation. The species and abundance of animals sighted would also be recorded. The Lead Scientist would ensure that the OTC is aware of all animals in or approaching the test site.

In addition to the operations vessel, the MART vessel would assist in pre-detonation monitoring using 25X binoculars and hand-held binoculars. The MART vessel would also have three marine biologists aboard with shipboard survey experience for waters of the proposed test. The MART vessel biologists would follow the same monitoring rotation and reporting protocol (i.e., biologist reporting to the Lead Scientist; Lead Scientist reporting to the Shock Test Director and OTC).

A small, fast boat (e.g., Zodiac or equivalent) would be deployed from the MART vessel to investigate selected beds of *Sargassum* for the presence of sea turtles. Generally, *Sargassum* beds attract smaller juvenile turtles which may be difficult to capture. If necessary, small turtles would be removed from the algae beds using a breakaway mesh net attached to an aluminum frame. The aluminum frame and net would be positioned via a long aluminum pole in front of the turtle. After the turtle swims into the net, a nylon drawstring would close the net which would then be detached from the frame and pulled onboard the Zodiac. Larger turtles swimming within the test site would be removed using a larger aluminum frame and net positioned from the MART vessel. All retrieved turtles would be temporarily held in a sun-protected area on the deck of the MART vessel until after the detonation. MART biologists would also tag and record any dead animals found in and near the test site prior to each detonation so that they are not counted as deaths caused by shock testing.

MART personnel would remain on station for a period of 48 hours after each detonation to monitor the test site and surrounding waters for injured or dead animals. If any animals are observed in the general area during the 48 hours post-detonation, the location, abundance, species, and behavior would be recorded. Depending upon their size, any injured or dead animals would be retrieved in an attempt to determine the cause of injury or death. The MART vessel would be assisted by the aerial monitoring team for three hours per day during the two days following each detonation. The aerial team would assist in the location of animals in the area and would direct the MART vessel to any sighted animals in the area that appear to be injured or dead.

5.5.3.3 Marine Mammal Acoustic Tracking System

The Marine Mammal Acoustic Tracking System (MMATS) is a portable, rapidly deployable signal processing system which would be used to detect and localize sources of transient acoustic signals produced by vocalizing marine mammals. The MMATS was successfully used during the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994). The system would consist of 10 to 15 moored acoustic receivers deployed from the MART vessel or, if necessary, from aircraft. The system includes a passive sonar processing mode. The positions of transient acoustic sources are determined by time-delay-of-arrival analysis; the system is capable of localizing to within 0.46 km (0.25 nmi) of the actual position of the source. Therefore, if an animal is acoustically detected within 4.3 km (2.3 nmi) of the detonation point, it would be assumed that the animal is within the 3.8 km (2.05 nmi) safety range; under these circumstances, no detonation would occur until it is confirmed that the animal's position is outside the 3.8 km (2.05 nmi) safety range. The MMATS configuration is shown in **Figure 5-2**.

The MMATS would monitor the frequency bandwidths between 15 Hz and 10 kHz (15 to 10,000 Hz). This frequency range covers the vast majority of calls produced by baleen and toothed whales, including the six species of endangered whales which may be found within the Mayport and Norfolk offshore areas [i.e., blue whale (*Balaenoptera musculus*): 10-30, 50-60, and 6,000-8,000 Hz; fin whale (*Balaenoptera physalus*): 20 and 1,500-2,500 Hz; humpback whale (*Megaptera novaeangliae*): 25-360, 750-1,800, and 100-4,000 Hz; northern right whale (*Eubalaena glacialis*): 160-500 and 50-500 Hz; sei whale (*Balaenoptera borealis*): 3,000 Hz; and sperm whale (*Physeter macrocephalus*): 2,000-4,000 and 10,000-16,000 Hz] (Richardson et al., 1991; Advanced Research Projects Agency, 1995).

5.5.4 Mitigation Phases

The mitigation plan consists of three phases:

- **Specific Test Site Selection Surveys** — selecting a suitable test site, 5.6 km (3 nmi) in radius, which poses the least risk to the marine environment;

- **Pre-Detonation Monitoring** — effectively monitoring that site prior to each detonation in an effort to ensure that it is free of marine mammals, turtles, large schools of fish, and flocks of seabirds; and

- **Post-Detonation Monitoring** — determining the effectiveness of the mitigation efforts, by using a Marine Animal Recovery Team (MART) and aerial observers to monitor the test site and surrounding waters for injured or dead animals after each detonation.

5.5.4.1 Test Site Selection Surveys

The purpose of the test site selection surveys is to select a site having the fewest marine mammals and turtles for the shock test. Two types of test site selection surveys would be conducted. First, aerial surveys three weeks prior to the first detonation

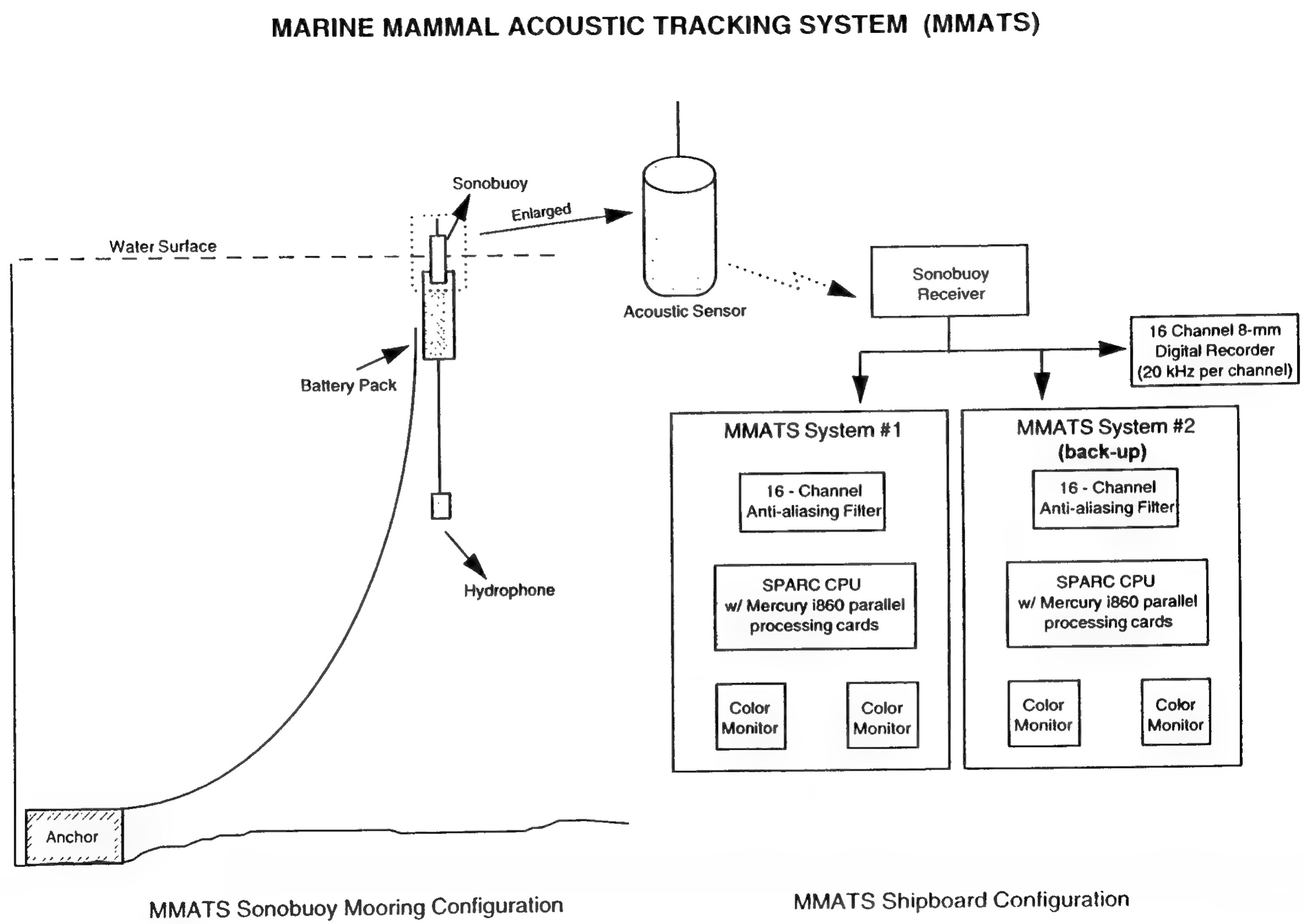


Figure 5-2. Marine Mammal Acoustic Tracking System (MMATS) sonobuoy mooring and shipboard configurations.

would provide data for selection of a primary test site and two secondary test sites. Second, aerial surveys two to three days before each detonation would confirm one of these as the final test site.

Three Weeks Prior to Detonation

Three weeks prior to the shock test, a single aerial survey would be conducted over the selected area (i.e., Mayport or Norfolk) to identify potential test sites with the lowest density of marine mammals and turtles. The selected area would be surveyed by flying east-west transects centered on the 152 m (500 ft) depth contour and extending approximately 7.4 km (4 nmi) to either side (**Figures 5-3 and 5-4**). From the sightings data, a single primary test site and two secondary test sites would be selected based on lowest relative abundance of marine mammals and turtles. Abundance totals would be determined initially in groups of five transects (e.g., transects 1 through 5, 2 through 6, etc.), which encompasses an area slightly larger than a potential test site. Sliding abundance totals for each transect group would then be compared to determine lowest relative abundance; transect groupings may also be enlarged (e.g., groups of 10 and/or 15) to allow greater flexibility in determining those sites with the lowest relative abundance.

Two to Three Days Prior to Detonation

An aerial survey would be conducted approximately at the three sites two to three days prior to each detonation (i.e., 24 to 36 hr prior to setting the array) in order to rank the sites by scarcity of marine mammals (**Figure 5-5**). Through the comparison of data collected during this survey, the selection of the primary and two secondary test sites will be confirmed. The proposed detonation point would lie at the center of each survey area, which measures 14.8 km x 14.8 km (8 nmi by 8 nmi). Through the comparison of data collected during this survey, a final test site selection would be made by the OTC, the Test Director, and the Lead Scientist.

5.5.4.2 Pre-Detonation Monitoring

The purpose of pre-detonation monitoring is to ensure that marine mammals and turtles are absent from the selected test site at the time of detonation. Two and one-half hours before each detonation, aerial and shipboard observers would begin to visually search for marine mammals and turtles. Two hours prior to detonation, MMATS monitoring would be conducted to detect vocalizing marine mammals.

Shipboard monitoring from the operations and MART vessels would focus on a 5.6 km (3 nmi) radius from the detonation point (encompassing the safety range and buffer zone) to preclude physical injury or mortality to marine mammals and turtles. Binoculars (25x power) mounted on the flying bridge or bridge wings of the two vessels would provide full 360° overlapping coverage. Other observers would use hand-held binoculars.

Shipboard monitoring from the MART vessel would be conducted by observers experienced in marine mammal observation. A veterinarian would coordinate the tagging and retrieval of any dead or injured animals discovered during aerial or shipboard

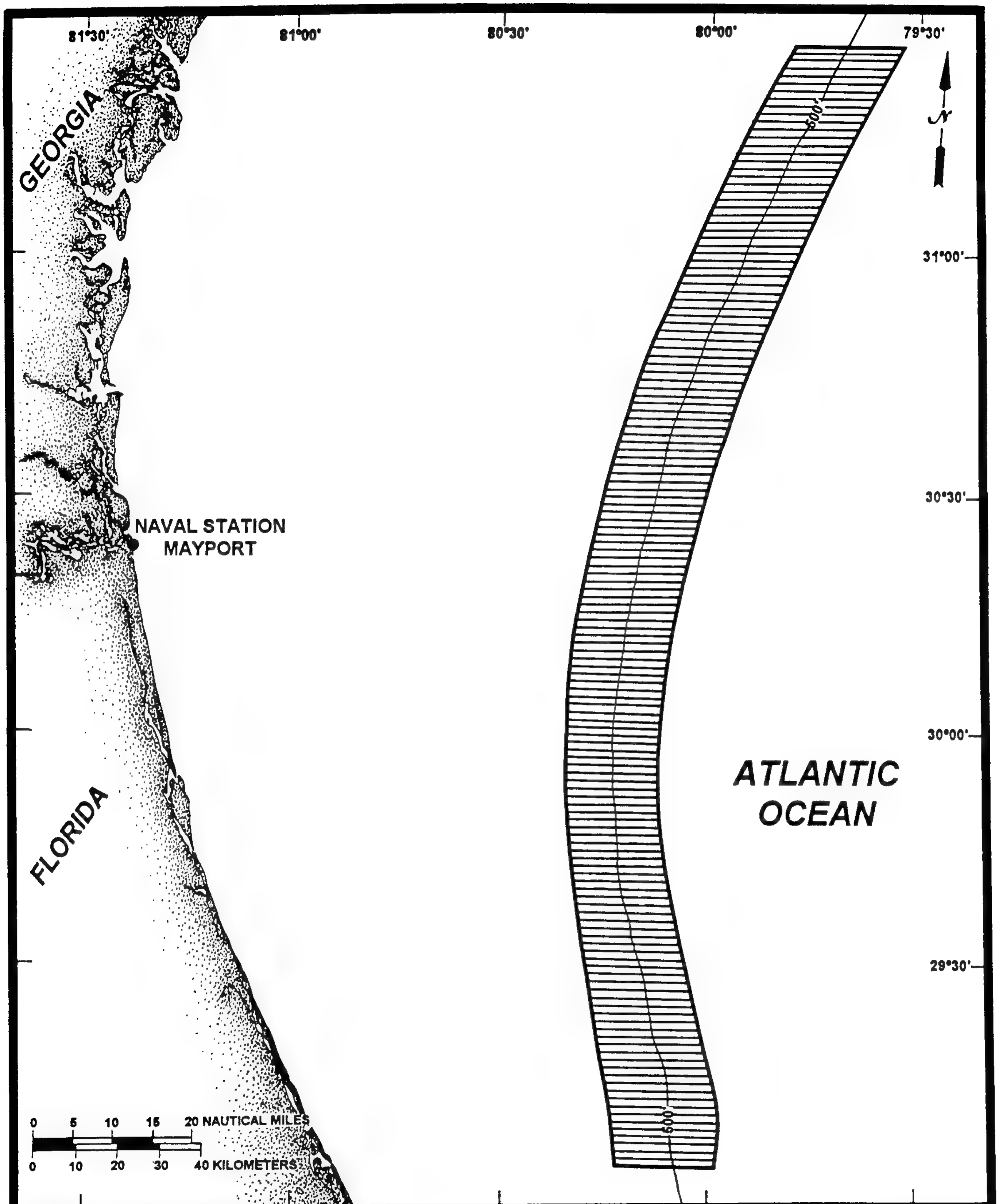


Figure 5-3. Location of aerial survey transects for test site selection three weeks prior to the shock test, if the Mayport area is selected.

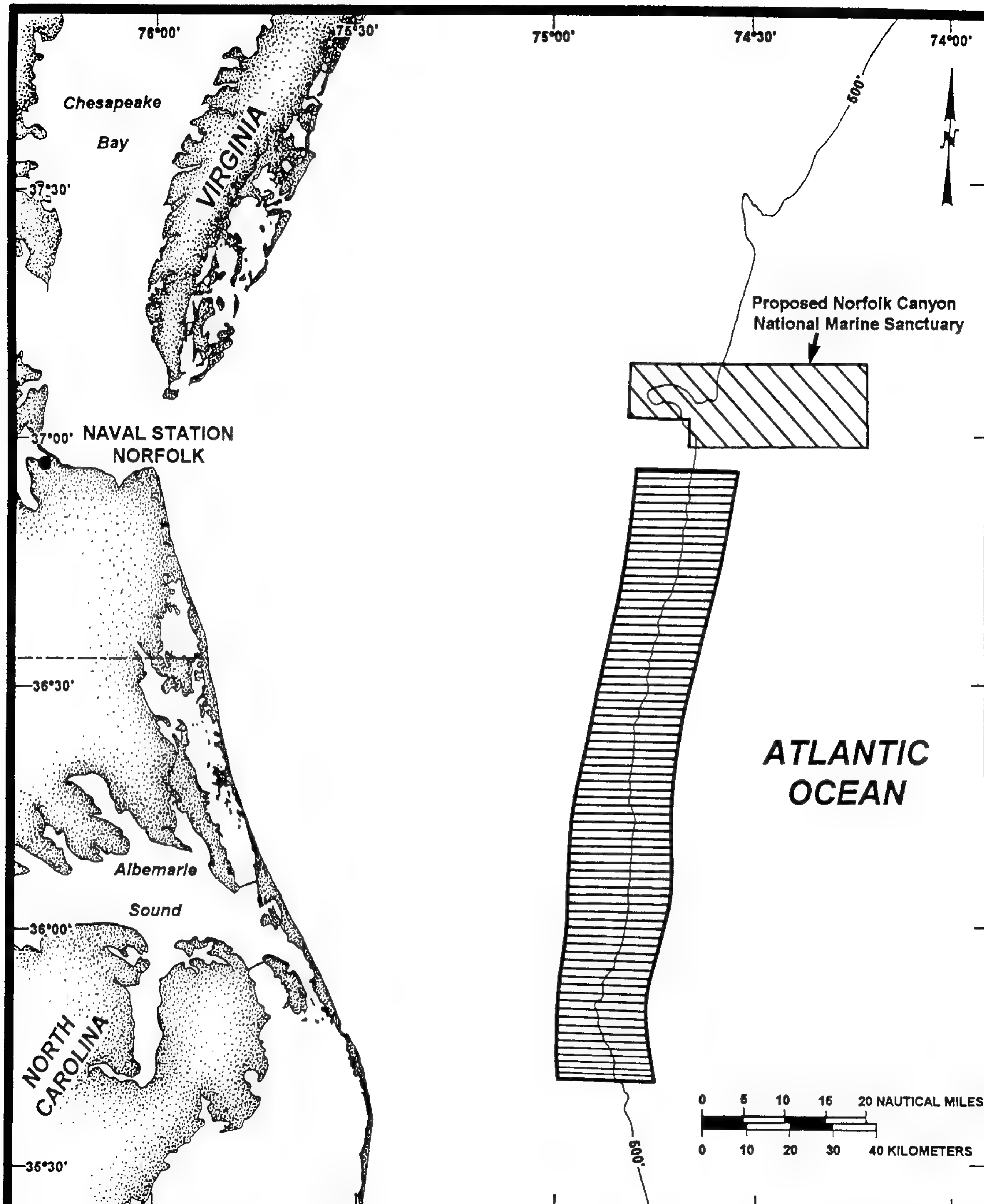


Figure 5-4. Location of aerial survey transects for test site selection three weeks prior to the shock test, if the Norfolk area is selected.

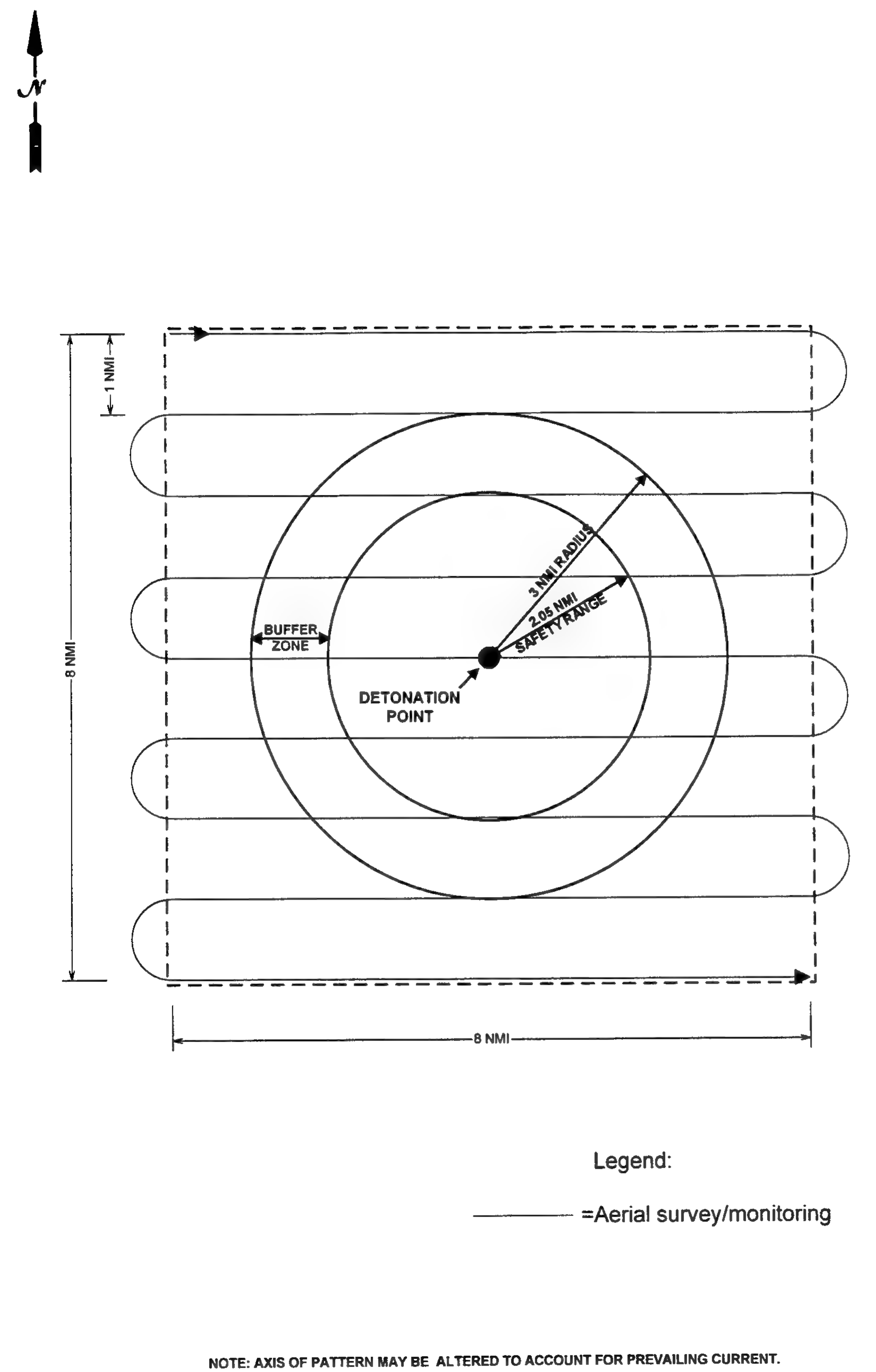


Figure 5-5. Flight plan two to three days and 2.5 hours prior to detonation.

pre-detonation monitoring. The MART responsibilities during pre-detonation monitoring are as follows:

- Deploy MMATS acoustic sensors;
- Conduct supplementary pre-detonation observations for marine mammals and turtles;
- Assist the aerial monitoring team in species identifications of selected individuals or groups; and
- Investigate large patches of *Sargassum* algae for the presence of juvenile sea turtles, and retrieve, as necessary.

Six Hours Prior to Detonation

Approximately six hours prior to detonation, the MART vessel would deploy 10 to 15 passive acoustic sensors (sonobuoys) throughout the test site; the total number of sensors to be deployed would depend upon ambient acoustic propagation and noise conditions in the vicinity of the detonation point. The sensors would be anchored to the bottom during the test, and would be retrieved afterwards. A representative pattern for sensor deployment, providing complete coverage of the test site, is illustrated in **Figure 5-6**. Deployment of the acoustic sensors in this pattern is intended to provide detection and localization of submerged marine mammals calls to a maximum distance of 14.8 km (8 nmi) from the detonation point for strong, low frequency calls common to whales and 3.9 km (2.1 nmi) for weak, high frequency calls common to dolphins.

Two and One-half Hours Prior to Detonation

Two and one-half hours prior to detonation, aerial monitoring would be conducted within the 14.8 km x 14.8 km (8 nmi x 8 nmi) monitoring area (see **Figure 5-5**). Shipboard observers on the operations and MART vessels would also monitor the test site from positions within a 5.6 km (3 nmi) radius of the detonation point. The MART vessel would deploy a Zodiac (or equivalent) to investigate large beds of *Sargassum* identified by the aerial team.

Two Hours Prior to Detonation

Two hours prior to detonation, the MMATS system would be calibrated. Two bioacousticians with extensive marine mammal vocalization (call) identification experience would monitor the system's receivers mounted onboard the operations vessel. Depending upon ambient oceanographic conditions, the MMATS team should have the ability to locate any vocalizing animals which may be approaching the test site. All noise signals would be interpreted, identified by species, and located. This information would be relayed to the Lead Scientist who would record the animal's location relative to the test site.

One Hour Prior to Detonation

One hour prior to detonation, monitoring of the area within a 5.6 km (3 nmi) radius of the detonation point would be performed (**Figure 5-7**) using a single aircraft, the MART vessel, and the operations vessel, enabling complete coverage of the test site prior

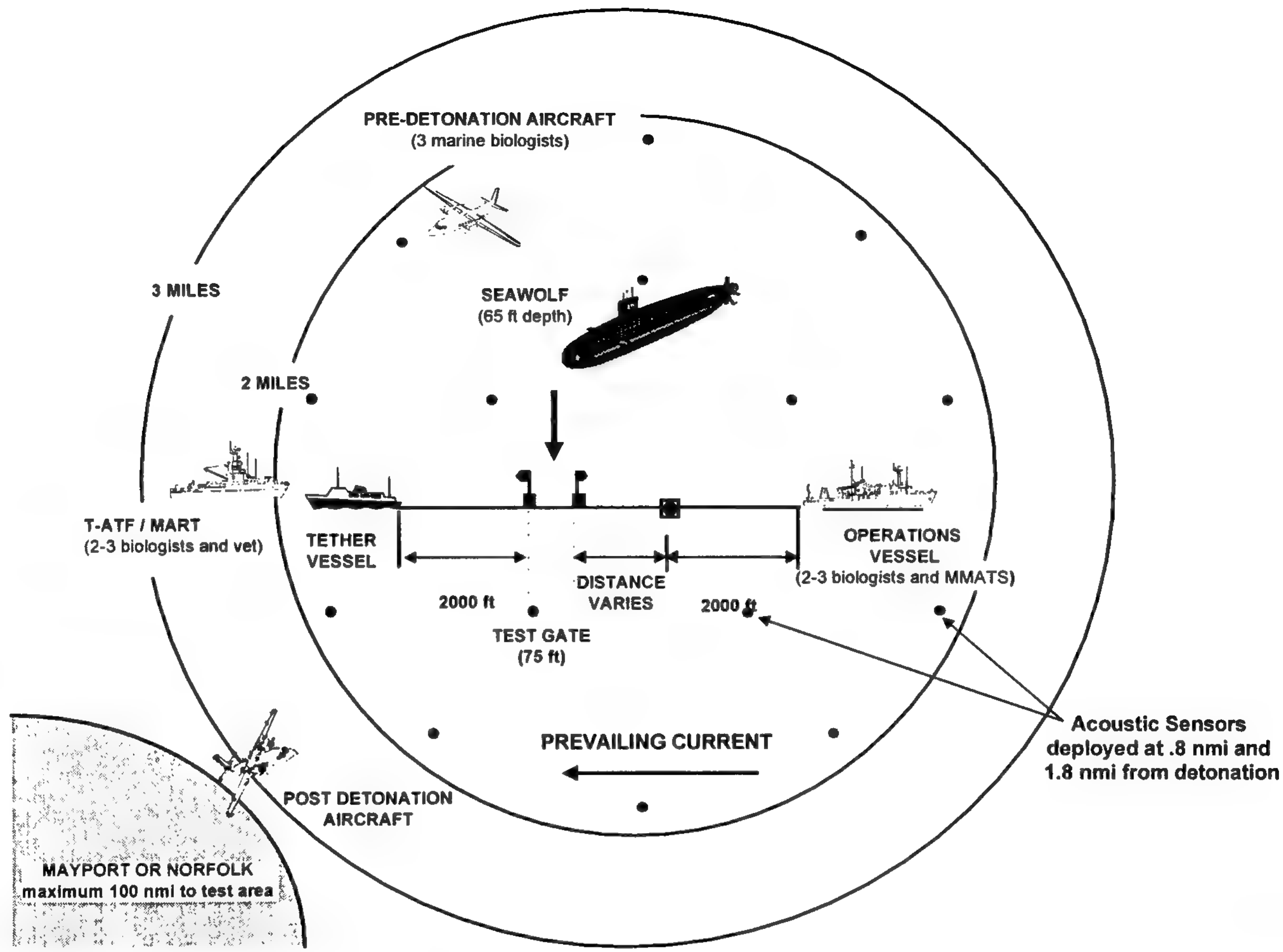


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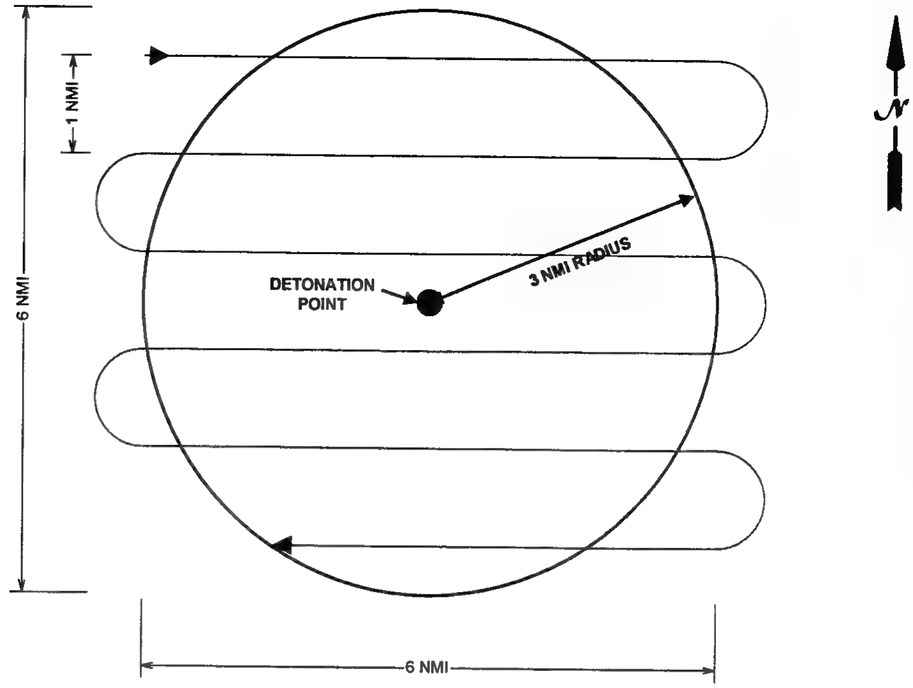
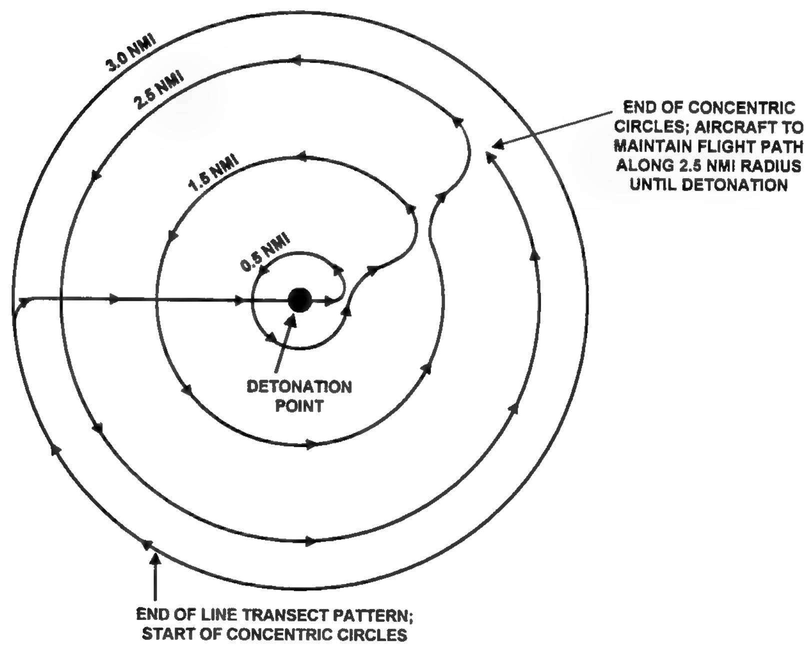
Figure 5-6. Sonobuoy deployment pattern relative to the three mile radius and the positions of the operations and MART vessels and detonation point.

(a)



(b)



Legend:

=Aerial monitoring

Figure 5-7. Flight plan 1.0 hour prior to detonation.

to detonation. Aboard the aircraft, observers would follow a line transect pattern, followed by overflight of the detonation point and a series of three concentric circles outward from the detonation point. The axis of the pattern may be altered to account for prevailing currents in the vicinity of the test site.

As reflected in **Figure 5-7(a)**, the initial phase of monitoring would consist of the line transect pattern, where a total of six east-west transects would be completed at 1.85 km (1 nmi) intervals. Following completion of the bottom east-west transect, the aircraft would follow the 5.6 km (3 nmi) radius to a point almost directly west of the detonation point. The aircraft would then turn east towards the detonation point. After crossing the detonation point, the aircraft would continue east to the 0.9 km (0.5 nmi) radius, turn northward, and complete the radius in a counter-clockwise direction. Once the 0.9 km (0.5 nmi) radius is completed, the aircraft would move to the 2.8 and 4.6 km (1.5 and 2.5 nmi) radii to complete each concentric circle in similar fashion. Once the final concentric circle is completed along the 4.6 km (2.5 nmi) radius, the aircraft would maintain this distance until after detonation. **Figure 5-6** illustrates the general position of all operational and mitigation assets during the pre-detonation period.

Flight lines [i.e., transects and concentric circles shown in **Figure 5-7(a)** and **5-7(b)**] are designed to search for marine mammals and turtles which may be present within 5.6 km (3 nmi) of the detonation point or that may swim into the safety range immediately prior to the detonation. While the initial east-west flight transects are intended to ensure that no marine mammals or sea turtles are present within the safety range, the overflight along the concentric circles is designed to further ensure that no mammals or turtles have entered the safety range during completion of the line transects. At a flight speed of 110 kt, completion of six line transects and five turns would require a total of less than 30 minutes (i.e., 3.3 min/transect; 1.7 min/turn). Completion of the concentric circles would require an additional 21 minutes. As noted previously, the aircraft would complete the 4.6 km (2.5 nmi) radius as the last of the concentric circles, holding that distance from the detonation point until detonation. This would assure effective monitoring of the buffer zone by the aerial team immediately prior to detonation. A summary of the distances and estimated travel times for each aerial monitoring component is provided in **Table 5-1**.

To account for marine mammals or sea turtles that may enter into the buffer zone and move towards the safety range during the period of time the aircraft is flying its transects, shipboard observers and the MMATS team would monitor the 5.6 km (3 nmi) (radius) test site. Shipboard observers would place emphasis on those portions of the test site that the aircraft has already monitored, while MMATS personnel would continue to monitor the entire test site.

Immediately prior to detonation and upon request of the OTC, the MART vessel would stand by at a distance of 3.7 km (2 nmi) from the detonation point. Detonation would not occur if: (1) any marine mammals or sea turtles were *visually* detected within 3.8 km (2.05 nmi) of the detonation point; (2) any marine mammals were *acoustically* detected within 4.3 km (2.3 nmi) of the detonation point (it would be assumed that the animal is within the 3.8 km (2.05 nmi) safety range); and (3) flocks of seabirds or large schools of fish were observed in the water within 1.85 km (1 nmi) of the detonation point.

Table 5-1. Distances and time required for completion of the aerial monitoring one hour prior to detonation.

Survey Component	Distance		Time Required (min)
	nmi	km	
Line Transects			
6 transects	36.0	66.6	19.8
5 turns	15.7	29.1	8.6
Total line transects	51.7	95.7	28.4
Concentric Circles			
To 0.5 nmi circle	6.0	11.1	3.3
0.5 nmi circle	3.14	5.81	1.7
From 0.5 nmi circle to 1.5 nmi circle	1.5	2.78	0.9
1.5 nmi circle	9.4	17.41	5.2
From 1.5 nmi circle to 2.5 nmi circle	1.5	2.78	0.8
2.5 nmi circle	15.7	29.1	8.6
Total concentric circles	37.24	68.98	20.5
TOTAL	**88.94 nmi**	**164.68 km**	**48.9 min**

5.5.4.3 Post-Detonation Monitoring

Post-detonation monitoring would be conducted by the MART vessel for a period of 48 hours after each detonation. The MART vessel would be assisted by the aerial mitigation team for up to three hours per day during the same 48 hours. Aerial and shipboard monitoring are intended to locate and identify any dead or injured animals. The MART would document any marine mammals or turtles that were killed or injured as a result of the shock test and, if practicable, recover and examine any dead animals. The behavior of any animals observed by MART and the aerial team would be documented.

Immediately Following Detonation

The aerial team would monitor the area of the test [5.6 km (3 nmi) radius] immediately following the detonation (**Figure 5-8**) and report any sightings of dead or injured marine mammals or turtles to the MART. After completing this initial monitoring of the test site, the aerial team would survey an 11.1 km (6 nmi) radius area from the detonation point, starting at the southern end and continuing north- or northeast-ward. Aerial monitoring, with transects spaced 1.85 km (1 nmi) apart, would continue northward for three hours after the detonation, or until sighting conditions are unsuitable (e.g., due to nightfall).

The MART vessel would move to the detonation point immediately following the detonation to search for dead fish or turtles, and then proceed to the top boundary of the 5.6 km (3 nmi) radius to search for any animals which have drifted with the current. Once at this position, the MART vessel would commence an 11.1 km (6 nmi) long racetrack pattern, centered 5.6 km (3 nmi) north of the detonation point (**Figure 5-8**) for one hour, intercepting any dead or injured marine animals drifting with the current. After one hour, the MART vessel would reposition an additional 3.7 km (2 nmi) north (or northeast, depending on prevailing current) of the detonation point and commence the same racetrack pattern for another hour. The MART vessel would continue to reposition in this manner until nightfall. MART would immediately break away from the racetrack pattern to investigate any sightings of potentially injured or dead marine animals reported by the aerial monitoring team.

Post-Detonation Days 1 and 2

Monitoring by the aerial team and MART would continue on post-detonation days 1 and 2 to detect any potentially injured or dead animals moving in the predominant direction and speed of the Gulf Stream (**Figure 5-9**). Drogues or lighted buoys deployed by the MART vessel would determine current attributes. Satellite imagery may also be used to further refine current speed and direction estimates. The aerial team would monitor for at least three hours each day, surveying transects 22.2 km (12 nmi) in length spaced 1.85 km (1 nmi) apart. Aerial transects would correspond to the position of the MART vessel and move progressively north- or northeastward.

As its first task on post-detonation days 1 and 2, the aerial team supporting the MART would return to the detonation point to observe and document the behavior of any animals in the area, after which they would move downcurrent to continue their observations. The MART vessel would continue the 11.1 km (6 nmi) long racetrack

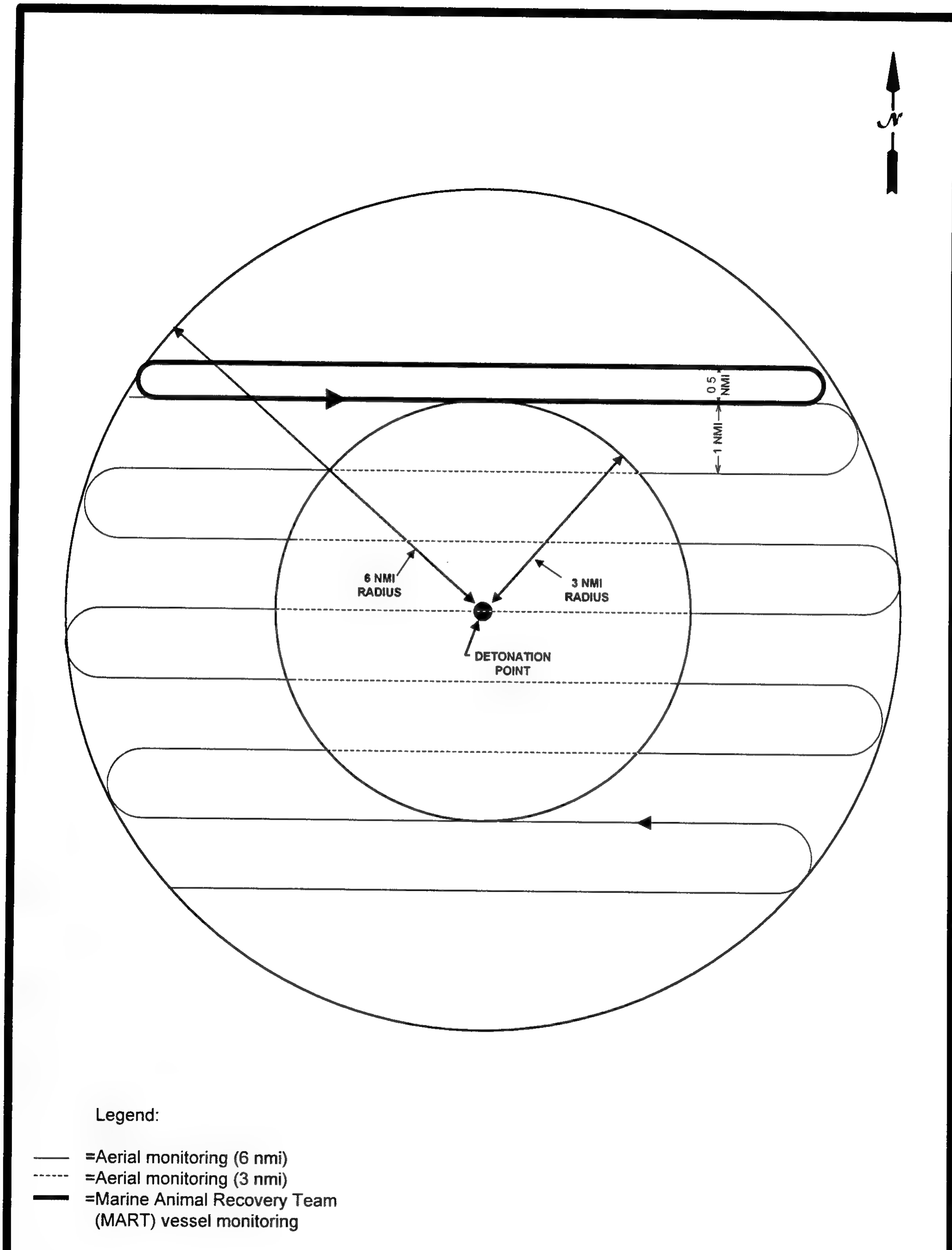


Figure 5-8. Flight and MART vessel plan immediately following detonation.

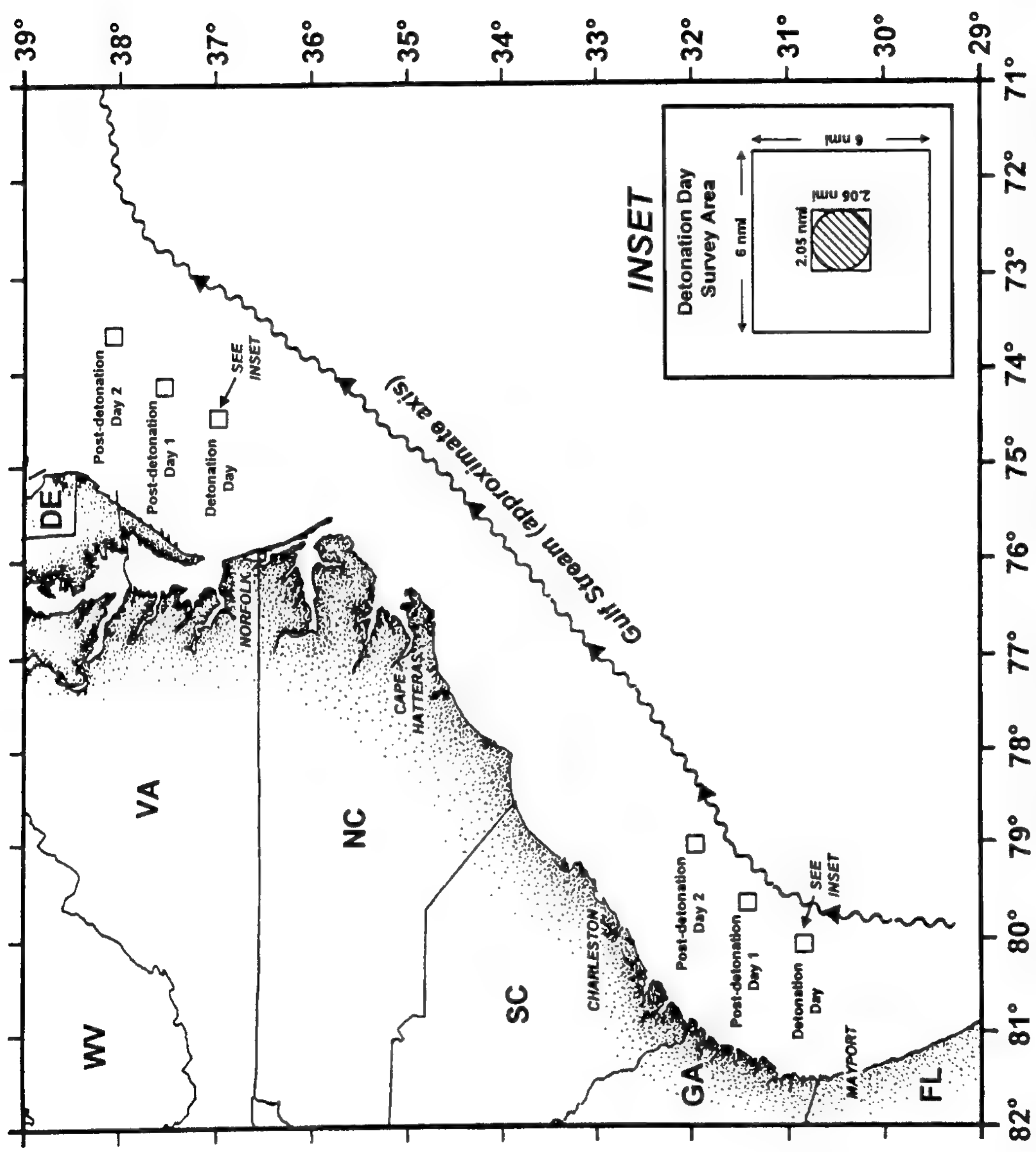


Figure 5-9. Projected location of post-detonation monitoring immediately following detonation and on post-detonation days 1 and 2.

pattern throughout the day, moving 3.7 km (2 nmi) northeast each hour. MART would immediately break away from the racetrack pattern to investigate any sightings of potentially injured or dead marine animals reported by the aerial monitoring team. At the end of post-detonation day 1, MART would deploy another drogue or lighted buoy to determine current direction and speed. The area to be monitored on post-detonation day 2 would be determined based on the results of the drift (**Figure 5-9**).

In total, the MART team would continuously monitor the area around the detonation site and areas downcurrent for at least 24 of the 48 hours following each detonation, covering approximately 444 km (240 nmi), based on two post-detonation monitoring days and an average vessel speed of 10 kt. The aerial team is expected to monitor as much as 1,833 km (990 nmi) during the same 48 hour period, based on a maximum of nine hours on station (i.e., three hours immediately after detonation, three hours each on post-detonation days 1 and 2) and an average flight velocity of 110 kt. If the post-detonation monitoring determines that injurious or lethal takes have occurred, a review and change of test procedures and monitoring methods would be made as necessary. A flow chart depicting the pre- and post-detonation MART action plan is shown in **Figure 5-10**.

Communications With Marine Animal Stranding Network(s)

The NMFS maintains regional stranding networks along the northeast (Maine to Virginia) and southeast (North Carolina to Texas, Puerto Rico, and the U.S. Virgin Islands) coasts to coordinate collection and dissemination of information about marine mammal strandings. The Lead Scientist would contact the designated coordinator of the appropriate stranding network after each detonation and report any observations of injured or killed marine mammals or turtles that cannot be recovered by the MART. Communications with stranding network personnel would be maintained throughout the SEAWOLF shock test period and any marine animal found stranded up to one month after the last test would undergo full necropsy to determine, as possible, cause of death.

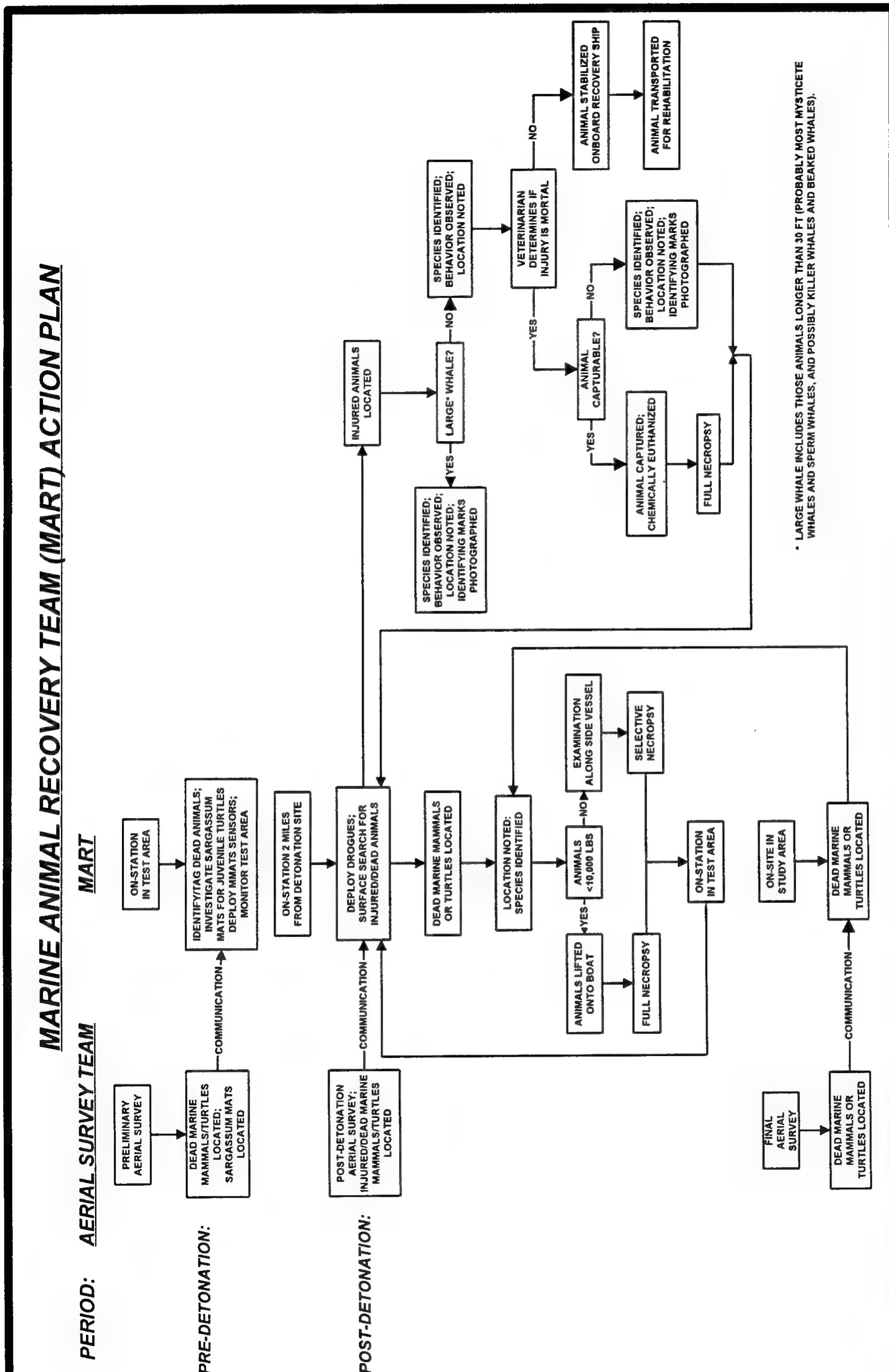


Figure 5-10. Flow chart depicting MART action plan during pre- and post-detonation periods.

6.0 CUMULATIVE IMPACTS

Cumulative impacts are those resulting from the incremental effects of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of which agency or person undertakes them. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over time.

As described in the Environmental Consequences section, the main impacts of the proposed shock testing would include release of chemical products into the ocean and atmosphere; deposition of metal fragments on the seafloor; mortality and injury of plankton and fish near the detonation point; possible mortality, injury, and acoustic discomfort of marine mammals and sea turtles; and possible interruption of commercial and recreational fishing activity in the test area. Because of the short-term nature of the proposed action and the minor and localized nature of the impacts, there would not be any incremental or synergistic impact on present or reasonably foreseeable future uses of either the Mayport or Norfolk area.

Shock testing would not be expected to result in accumulation of explosion products in the water column or atmosphere. Both the Mayport and Norfolk areas are in deep, oceanic waters where the explosion products would be rapidly dispersed and mixed. Gases released into the atmosphere would also be rapidly dispersed and mixed. As stated in Sections 4.2.1.1 and 4.2.2.5, metal fragments from the explosions would accumulate on the seafloor but would not be expected to produce adverse impacts; they would provide a substrate for growth of epibiota and attract fish.

The Navy is currently designing the New Attack Submarine (NSSN). The Navy's Live Fire Test and Evaluation Plan for the NSSN includes a ship shock test in 2005. The technical and operational requirements to shock test the NSSN would be similar to SEAWOLF and therefore, both the Mayport and Norfolk areas may be considered as potential shock test areas in the future. Other than the shock testing of the NSSN, there are no ongoing, planned, or reasonably foreseeable Navy actions which could have similar impacts on the marine environment at either the Mayport or Norfolk area. No other shock testing has been proposed for either area during this time period. The petroleum industry has proposed offshore drilling at a location south of the Norfolk area (DOI, MMS, 1990), but the proposal has been postponed indefinitely (Oil and Gas Journal, 7 August 1995, p. 34). Commercial and recreational fishing at both Mayport and Norfolk targets some of the same fish species which may be killed or injured by the proposed action; however, no cumulative impact on fisheries is expected because the fish species are abundant and widely distributed.

Pursuant to its authority and responsibilities under the Endangered Species Act, the NMFS will issue a Biological Opinion taking into account the cumulative impacts of all activities potentially affecting listed marine mammal and turtle populations. The proposed action cannot occur unless the Biological Opinion concludes that shock testing is not likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat.

7.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

Unavoidable impacts of the proposed shock testing include release of chemical products into the ocean and atmosphere, deposition of metal fragments on the seafloor, mortality and injury of plankton and fish near the detonation point, possible acoustic discomfort of marine mammals and sea turtles, and possible interruption of commercial and recreational fishing activity in or near the test site.

Underwater explosions would release chemical products into the ocean and atmosphere and deposit metal fragments on the seafloor. Due to the low initial concentrations and rapid dispersion of the chemical products, they would pose no hazard to marine or human life. The metal fragments would not be expected to produce adverse impacts; they should provide a substrate for growth of epibiota and attract fish.

Fish near the detonation point would be killed or injured. A large fish kill would not be expected because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point. No impact on fish populations, including commercial and recreational species, is expected because the fish found at the Mayport and Norfolk areas are abundant and widely distributed. Plankton and other small marine life would also be affected but would be rapidly replenished through population growth and mixing with adjacent waters.

Most potential impacts to marine mammals and sea turtles would be avoidable due to the mitigation procedures described in Section 5.0. Because detonations would not occur if any marine mammals or turtles were detected within the safety range, mortality or injury is unlikely. However, because no method of detection can be 100% effective, some marine mammals and/or sea turtles could be killed or injured if present within the safety range. Also, mammals or turtles beyond the safety range could experience acoustic discomfort due to the acoustic characteristics of the shock wave. This momentary disturbance would not be expected to have any lasting effects on the animals. The potential impacts on marine mammals and sea turtles are also addressed in the Navy's Request for Letter of Authorization for the Incidental Take of Marine Mammals and in the Biological Assessment (Appendix G).

Fishing vessels and other ship traffic would be excluded from the test site before, during, and after each shock test. Due to the short duration of the tests and advance warning through *Notices to Airmen and Mariners*, the interruption is not expected to significantly affect commercial or recreational fisheries or other ship traffic.

8.0 ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL

Shock testing would require expenditure of energy in the form of fuel consumed by vessels and aircraft. Fuel would be used by the SEAWOLF submarine, which is the platform to be shock tested, by ships associated with placing the test array and detonating the charge, and by ships and aircraft involved in mitigation and clearing the site. Because the shock test site would be located near required Navy facilities, energy consumed by vessels and aircraft would be conserved by minimizing transit distances and keeping the time at sea to a minimum.

9.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Shock testing would result in commitments of labor and capital along with use of non-renewable materials. Fuel used by vessels and aircraft during shock testing, as well as non-recyclable materials used for engine maintenance, are irretrievable resources. Mitigation efforts will minimize the effects of the proposed action on the marine environment, and no irreversible or irretrievable commitment of marine resources is expected.

10.0 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed action will allow the Navy to assess the survivability of the SEAWOLF submarine in accordance with 10 USC 2366. Shock test operations will have no significant long-term impacts on the environment. Shock testing of the SEAWOLF is being proposed as a short-term action which includes five detonations between 1 April (1 May for the Mayport area) and 30 September 1997. Short-term commitments of labor and capital along with use of non-renewable materials for machine power and maintenance would result from the proposed activities. No long-term commitments of resources would be required. The location of the test site in offshore waters will minimize biological effects because productivity is expected to be lower than in nearshore waters. Mitigation monitoring using visual and passive acoustic surveillance techniques will minimize the effects of the proposed action on marine resources and improve knowledge of the marine environment in the area. The only long-term effect from the operations will be a limited distribution of small steel fragments from the charge container on the seafloor. Although the fragments could slightly enhance benthic productivity by increasing available substrate for the attachment of marine invertebrates, this effect is considered insignificant. All other effects would be temporary in nature; individual marine organisms may be killed or injured as a result of underwater detonations, but there should be no lasting impact on population levels of any species. Therefore, the activities should have no significant adverse or beneficial long-term impacts on the maintenance and enhancement of long-term biological productivity.

11.0 RELATIONSHIP WITH FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

11.1 NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA) of 1969, as amended, contains policy and guidance to ensure that potential impacts from proposed federal actions are assessed using a systematic and interdisciplinary approach. This DEIS has been prepared in accordance with Section 102(2)(c) of NEPA, the Council on Environmental Quality (CEQ) regulations on implementing NEPA procedures (40 CFR 1500-1508), and Department of the Navy regulations on implementing NEPA procedures (32 CFR 775).

11.2 EXECUTIVE ORDER 12114

Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions," requires analysis of environmental impacts of Federal agency actions that could significantly affect the global commons, the environment of a foreign nation, or impacts on protected global resources. Executive Order 12114 is based on independent authority but furthers the purpose of NEPA. Because the proposed action could result in environmental impacts outside of U.S. territorial seas, this DEIS has been prepared in accordance with Executive Order 12114. Impact discussions in this DEIS (Section 4.0, Environmental Consequences) are divided into separate subsections to distinguish between those operations that are evaluated under NEPA and those that are evaluated under Executive Order 12114.

11.3 EXECUTIVE ORDER 12898

Consistent with Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," it is the Navy's policy to identify and address disproportionately high and adverse human health or environmental effects on members of minority and low-income populations. Shock testing and associated mitigation operations would occur well offshore and would result in minor and/or temporary impacts to the environment at the test site with no significant direct or indirect impacts on the human population. Chemical byproducts of the detonations would be rapidly dispersed at the test site (Sections 4.2.1.2 and 4.2.1.3) and therefore would not affect coastal water quality or air quality. Due to the small area affected and the short duration of shock testing, the proposed action would not have significant impacts on commercial or sport fishery stocks, fishing activities (including subsistence fishing), or the coastal fishing industry (Section 4.1.3). Existing and temporary facilities at Naval Station Mayport and Naval Submarine Base Kings Bay or Naval Station Norfolk would provide all services in support of shock testing, and no significant direct or indirect impacts on the local economy are expected (Section 4.1.3). The shore-based operations and transit of ships and aircraft from shore support facilities to the test site are of the same type routinely conducted by the Navy and would not involve any unusual or extraordinary activities which could have impacts on coastal resources or the coastal economy. Therefore, the proposed action would not have any adverse impacts on the human population and would not have a disproportionately high effect on any minority or low-income group.

11.4 ENDANGERED SPECIES ACT

The Endangered Species Act of 1973, as amended, empowers the Secretary of the Interior to establish a listing of endangered and threatened species and critical habitats designated for protection. The Act prohibits jeopardizing endangered and threatened species or adversely modifying critical habitats essential to their survival. Copies of the Department of the Navy, NMFS, and USFWS informal consultation letters written prior to preparation of the DEIS are provided in Appendix C. No formal consultation with the USFWS will be required because there are no endangered and threatened species or critical habitats under USFWS jurisdiction that could be affected by the proposed action (i.e., the USFWS has already completed its responsibilities under the Endangered Species Act). However, formal consultation with the NMFS will be required. The DEIS includes a Biological Assessment (Appendix G) which the Navy has submitted to the NMFS to initiate formal consultation. Formal consultation will end when the NMFS delivers a Biological Opinion to the Navy.

11.5 MARINE MAMMAL PROTECTION ACT

The Marine Mammal Protection Act of 1972, as amended, establishes a national policy designed to protect and conserve marine mammals and their habitats. This policy is established to prevent the reduction of population stocks beyond the point at which they cease to be a functioning element in the ecosystem, or the reduction of species below their optimum sustainable population. For the proposed action, the Navy will be submitting a small take application to the NMFS. The USFWS will not be involved because there are no marine mammal species under USFWS jurisdiction that could be affected by the proposed action. The small take application initiates the NMFS rule-making and public review process. The process ends with the NMFS issuing a Letter of Authorization for incidental take pursuant to regulations which specify the permissible take limitations and required mitigation measures.

11.6 MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

The Marine Protection, Research and Sanctuaries Act of 1972 (Ocean Dumping Act), as amended, makes it illegal for any person to transport material from the U.S. for the purpose of dumping it into ocean waters. The term "dumping" as defined under the Act does not include the intentional placement of any device in ocean waters for a purpose other than disposal. In the case of the proposed action, the explosive charge would be transported for the purposes of detonating the charge and conducting the shock test. After each detonation, the test array would be recovered and floats and floating debris would be removed. Thus, shock testing would not involve transporting material for the purpose of dumping it into ocean waters, and the proposed action would not require an ocean dumping permit.

The probability of a charge not detonating during a test is remote. Should a charge fail to explode, the Navy would attempt to identify the problem and detonate the charge (with all mitigation measures, Section 5.0). If these attempts failed, the Navy would recover the explosive and disarm it. Only in case of an extreme emergency or to safeguard human life would the Navy dispose of the charge at sea.

11.7 COASTAL ZONE MANAGEMENT ACT

The Coastal Zone Management Act of 1972, as amended, provides for the effective management, beneficial use, protection, and development of the U.S. coastal zone. The Act enables individual states to develop and implement regulatory guidelines to ensure appropriate protection and compatibility of uses within their coastal zones. The shore-based operations and transit of ships and aircraft from shore support facilities to the test site would have no effects on coastal resources. Shore facility operations and ship and aircraft transits are of the same type routinely conducted by the Navy and would not involve any unusual or extraordinary activities. As the shock testing itself would occur well outside state waters and coastal zones, it would not directly or indirectly affect coastal resources of any state. Chemical byproducts of the detonations would be rapidly dispersed at the test site (Sections 4.2.1.2 and 4.2.1.3) and therefore would not affect coastal water quality or air quality. Due to the small area affected and the short duration of shock testing, the proposed action would not have significant impacts on commercial or sport fishery stocks, fishing activities, or the coastal fishing industry (Section 4.1.3). Existing and temporary facilities at Naval Station Mayport and Naval Submarine Base Kings Bay or Naval Station Norfolk would provide all services in support of shock testing, and no significant direct or indirect impacts on the local economy are expected (Section 4.1.3). The coastal tourist industry would not be affected by floating debris or dead fish; what little floating debris may result from the detonations would be removed, and any fish killed or injured by the explosions would be expected to drift to the northeast with the Gulf Stream and would not reach coastal waters (Section 4.1.3).

11.8 MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act of 1918 (MBTA), as amended, regulates the taking, killing, and possession of migratory birds within U.S. territory. The MBTA applies to migratory birds as defined in the terms of conventions between the U.S. and Great Britain, Mexico, Japan, and the Union of Soviet Socialist Republics. Many of the seabird species which could occur at the Mayport or Norfolk areas are migratory birds as defined in the act. No taking or killing of migratory birds would result from those portions of the proposed action taking place within U.S. territory at shore support facilities or during transit of ships and aircraft to the test site. While the MBTA does not apply, the Navy will make every effort to prevent and/or minimize harm to migratory seabirds which may be in the vicinity of the test site during detonation. The mitigation plan set out in Section 5.0 of the DEIS includes a provision for postponing detonations if flocks of birds are present within the safety range.

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APPENDIX A

DISTRIBUTION LIST FOR THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

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DISTRIBUTION LIST FOR THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

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[3] = Requested DEIS in written scoping comments
[4] = Attended public scoping meeting but did not request DEIS
[5] = Submitted written scoping comment but did not request DEIS

APPENDIX B

TECHNICAL INFORMATION CONCERNING MARINE MAMMALS, TURTLES, AND BIRDS

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APPENDIX B

TECHNICAL INFORMATION CONCERNING MARINE MAMMALS, TURTLES, AND BIRDS

B.1 MARINE MAMMALS

B.1.1 Species Descriptions of Listed Marine Mammals

Fin whales (*Balaenoptera physalus*) range from the Arctic to the Greater Antilles, including the Gulf of Mexico. They are usually found inshore of the 2,000-m (6,562-ft) contour. This species occurs widely in the middle Atlantic throughout the year, with concentrations from Cape Cod north in summer and from Cape Cod south in winter. This species is frequently found along the New England coast from spring to fall in areas of fish concentration. It is thought that fin whales migrate north nearshore along the coast during spring and south offshore during winter. This species feeds on krill, planktonic crustaceans, and schooling fish such as herring and capelin. It is believed that fin whales breed in the middle Atlantic, with mating and calving occurring from November to March. Gestation lasts about 1 year and calves are suckled for 7 months. Fin whales off the eastern U.S. to Canada constitute a single stock (Blaylock et al., 1995). The minimum population estimate for this species in the western Atlantic was 1,704 individuals, based on a 1991-92 shipboard survey (Blaylock et al., 1995).

Blue whales (*Balaenoptera musculus*) range from the Arctic to at least mid-latitudes including the waters of the Gulf of Mexico. This species is pelagic, primarily found feeding north of the Gulf of St. Lawrence during spring and summer. It is considered as a very occasional species in waters off the eastern U.S. (Blaylock et al., 1995). Limited migration has been documented south to subtropical waters during fall and winter. This species feeds on krill and copepods, the abundance of which most likely controls migration in and out of polar areas. Mating and calving occurs in late fall and winter. Gestation lasts 10 to 11 months. Calves are born every 2 to 3 years. Blue whales are usually seen solitary or in groups of 2 or 3 individuals. Existing data are insufficient for stock differentiation and population estimates in the Atlantic (Blaylock et al., 1995).

Sei whales (*Balaenoptera borealis*) range from south of the Arctic to northeast Venezuela, including the Gulf of Mexico. This species is considered to be pelagic and widely distributed from below polar seas to the Caribbean. It is believed that the following three main stocks occur: 1) Newfoundland/Labrador; 2) Nova Scotia; and 3) Caribbean/ Gulf of Mexico. The Nova Scotia stock migrates along the coast, with occurrence south of Cape Cod in winter and from Cape Cod north to the Arctic in summer. This species feeds on copepods, krill, and small schooling fish such as anchovies, sauries, and mackerel. Peak pairing is reported to be from November to February in temperate waters. Gestation lasts 1 year and calves are born in February in warmer waters. Calves are suckled for 6 months. Large numbers concentrate in feeding grounds but usually travel in groups of 2 to 5 individuals. Existing data are insufficient for obtaining estimates of population size in the Atlantic (Blaylock et al., 1995).

Humpback whales (*Megaptera novaeangliae*) range from the Arctic to the West Indies, including the Gulf of Mexico. They are found in middle Atlantic shallow coastal waters during spring and in waters around Cape Cod to Iceland during late spring to fall. During summer there are at least five geographically distinct feeding aggregations in the northern Atlantic. Generally, their distribution has been largely correlated to prey species and abundance (Blaylock et al., 1995). It is thought that migration south to the Caribbean occurs during fall. This species feeds largely on euphausiids and small fish such as herring, capelin, and sand lance. Calving and breeding occurs in the Caribbean from January to March. Gestation lasts 10 months and calves are suckled for about 11 months. Critical habitats have been identified in the western Gulf of Maine and the Great South Channel (Massachusetts). The minimum population estimate for the North Atlantic range of the humpback whale is 4,865 individuals (Blaylock et al., 1995).

Sperm whales (*Physeter macrocephalus*) range from the Davis Straits to Venezuela, including the Gulf of Mexico. This species is pelagic, occurring along the continental shelf edge and slope, continuing into mid-ocean areas; it is occasionally found on the shelf. Sperm whales generally feed on mesopelagic (open ocean environment between 150 and 1,000 m [492 and 3,281 ft] depth) squid along the 1,000-m (3,281-ft) contour. North-south migratory routes observed through middle Atlantic areas are always inhabited. Females, calves, and juveniles remain south of 40°N to 42°N latitude throughout the year while mature males range to higher latitudes (68°N) during summer. This species is most abundant during spring. Mating season is prolonged, extending from late winter through early summer. Calves are born once every 3 to 6 years. Calving occurs between May and September in the northern hemisphere. Large, old males are solitary, while females, calves, and juveniles form "breeding schools" with 4 to 150 individuals. Young males form segregated bachelor groups, or "schools", of up to 50 individuals. The sperm whales which occur along the eastern U.S. represent only a fraction of the total stock. The nature of linkages of this habitat with others is unknown. Their minimum population estimate is 226 individuals (Blaylock et al., 1995).

Northern right whales (*Eubalaena glacialis*) range from Iceland to eastern Florida, with occasional sightings in the Gulf of Mexico. This is the rarest of the world's baleen whales, with a current North Atlantic population between 325 and 350 individuals (Kraus et al., 1993). Coastal waters of the southeastern United States (off Georgia and northeast Florida) are important wintering and calving grounds for northern right whales, while the waters around Cape Cod and Great South Channel are used for feeding, nursery, and mating during summer (Kraus et al., 1988; Schaeff et al., 1993). From June to September, most animals are found feeding north of Cape Cod. Right whale mating probably occurs during late summer; gestation lasts 12 to 16 months, and calves are suckled for about one year (Knowlton and Kraus, 1989). Southward migration occurs offshore from mid-October to early January, although right whales may arrive off the Florida coast as early as November and may stay into late March (Kraus et al., 1993). Migration northward along the coast of Florida takes place between early January and late March. Coastal waters off the Carolinas may represent a migratory corridor for this species (Winn et al., 1986; Kraus et al., 1993). It has been suggested that during the spring migration, right whales typically transit offshore North Carolina in shallow water immediately adjacent to the coast; fall migrations may occur further offshore in this region (Department of the Interior, Minerals Management Service, 1990). This species usually occurs shoreward of the 200-m (656-ft) contour line. Preferred water depths during

recent surveys off the Florida coast range from 3 to 73 m (10 to 240 ft), with a mean of 12.6 m (41.3 ft) (Kraus et al., 1993).

Designated critical habitat for the northern right whale includes portions of Cape Cod Bay and Stellwagen Bank and the Great South Channel (off Massachusetts) and waters adjacent to the coasts of Georgia and northeast Florida (Federal Register 59(106):28793-28808). The southernmost critical habitat (**Figure B-1**) encompasses "waters between 31°15'N (i.e., near the mouth of Altamaha River, Georgia) and 30°15'N (i.e., near Jacksonville, Florida) from the shoreline out to 15 nautical miles offshore, and the waters between 30°15'N and 28°00'N (i.e., near Sebastian Inlet, Florida) from the shoreline out to 5 nautical miles."

B.1.2 Species Descriptions of Nonlisted Marine Mammals

Nonlisted marine mammals that may occur in the area include both baleen whales and toothed whales. Two nonlisted baleen whale species may occur within the area: the minke whale (*Balaenoptera acutorostrata*) and Bryde's whale (*Balaenoptera edeni*). Both are in the Family Balaenopteridae (rorquals). In addition, 21 nonlisted toothed whale species may occur within the area, including representatives of four families (i.e., Ziphiidae, Kogidae, Stenidae, and Delphinidae).

B.1.2.1 Baleen Whales

Minke whales (*Balaenoptera acutorostrata*) have a widespread distribution in polar, temperate, and tropical waters. There are four recognized minke whale populations in the North Atlantic. Minke whales off the U.S. eastern seaboard are considered part of the Canadian East Coast population which covers the area from the eastern half of the Davis Strait out to 45°W and south to the Gulf of Mexico (Blaylock et al., 1995).

Along the U.S. east coast, the minke whale is the third most common large whale in the region (Cetacean and Turtle Assessment Program [CETAP], 1982). Blaylock et al. (1995) noted a strong seasonal component to minke whale distribution, with widespread and common occurrence of this species off the eastern coast of the U.S. in spring and summer. Minke whales are observed north of Cape Cod in summer, commonly in nearshore waters of the Gulf of Maine and Bay of Fundy. Migrations occur northward during spring and southward in fall. It is believed that this species spends winter offshore of south Florida and the Lesser Antilles. Mitchell (1991) suggested a possible winter distribution in the West Indies and the mid-ocean south and east of Bermuda. Lee (1985a) indicated that minke whales may winter off the North Carolina coast, but are absent during other seasons. Manomet Bird Observatory (1989) recorded rare sightings of this species in summer, autumn, and winter (i.e., 2 to 5 individuals/ 100 transects) on the shelf north of Cape Hatteras. Sightings typically occur nearshore or within the 200-m (656-ft) contour. Like most other baleen whales, minke whales typically occupy the shelf proper, rather than the shelf edge (Blaylock et al., 1995). Preferred prey include herring, cod, salmon, capelin, squid, and shrimp (Leatherwood et al., 1976). Pairing is normally observed during October to March, coincident with calving. Gestation is about 10 to 11 months; nursing lasts for less than 6 months. It is believed that this species is more solitary though large groups have been observed. The minimum

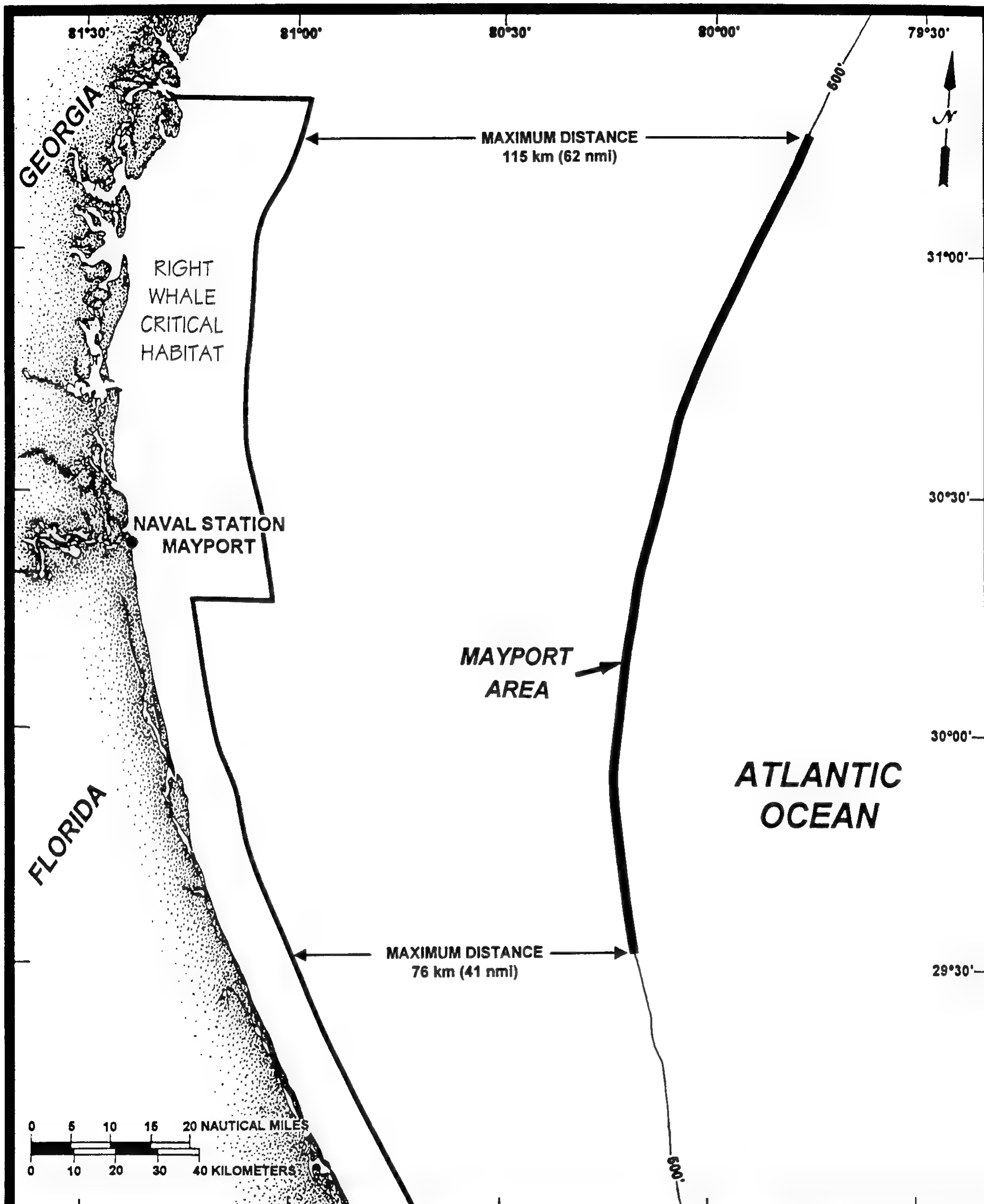

Figure B-1. Location of the northern right whale critical habitat in relation to the Mayport area.

population estimate of minke whales in the eastern U.S./Canadian population is unknown (Blaylock et al., 1995). Minke whale abundance data acquired by shipboard surveys conducted during 1991-92 estimated 2,053 individuals (Blaylock et al., 1995).

Bryde's whales (*Balaenoptera edeni*) range from off the southeastern United States including the Gulf of Mexico, to the southern Caribbean Sea and Brazil (Leatherwood and Reeves, 1983). This species is found primarily in tropical and subtropical waters, and seldom occurs above 40°N except in warm-water (above 20°C [68°F]) projections northward. Bryde's whales are not thought to undergo long migrations. Some northward movements during summer and southward movements during winter have been observed and suggest pursuit of prey. This species typically inhabits nearshore waters and feeds on schooling fish such as sardines, mackerel, anchovies, and herrings. Bryde's whales are relatively uncommon. Information from South African waters suggests they breed year round.

B.1.2.2 Toothed Whales and Dolphins

Family Ziphiidae. There are six species of beaked whales which occur in the Mayport and Norfolk areas (Leatherwood et al., 1976; Blaylock et al., 1995), including the Northern bottlenose whale (*Hyperoodon ampullatus*), Blainville's beaked whale (*M. densirostris*), Gervais' beaked whale (*M. europaeus*), True's beaked whale (*M. mirus*), Sowerby's beaked whale (*M. bidens*), and Cuvier's beaked whale (*Ziphius cavirostris*). The members of the genus *Mesoplodon* are difficult to identify to the species level at sea. Therefore, much of the available characterization for these species is to genus level only. Similarly, the elusive nature of *Mesoplodon* spp. has, to date, prevented the acquisition of sufficient data to determine specific population trends (Blaylock et al., 1995). Beaked whales are currently classified as a "strategic stock" by the National Marine Fisheries Service (NMFS) (Blaylock et al., 1995).

Northern bottlenose whales (*Hyperoodon ampullatus*) are found only in temperate to arctic waters of the North Atlantic. They follow a relatively well-defined migratory pattern, and are found at low latitudes only during winter (Leatherwood and Reeves, 1983). They are deep divers and appear to feed primarily on squid and fish (Leatherwood and Reeves, 1983; Jefferson et al., 1993). They are characterized as extremely uncommon or rare in the northern Atlantic, and current data are insufficient to determine population size (Blaylock et al., 1995).

Blainville's beaked whales (*Mesoplodon densirostris*) range from Nova Scotia to Florida and the Bahamas, including waters of the Gulf of Mexico. This species is considered pelagic, inhabiting very deep waters. It is widely but sparsely distributed throughout tropical and warm temperate waters up to 45°N latitude in the western Atlantic due to the presence of the Gulf Stream (Leatherwood et al., 1976). Data suggest that Blainville's beaked whales feed on squid and live in family groups of 3 to 6 individuals. Little is known about the life history of this species.

Gervais' beaked whales (*Mesoplodon europaeus*) are considered pelagic, and strandings have been reported from the Middle Atlantic Bight to Florida into the Caribbean and the Gulf of Mexico (Blaylock et al., 1995). Data suggest that the preferred prey of this species is squid.

True's beaked whales (*Mesoplodon mirus*) are a temperate water species that has been reported from Cape Breton Island, Nova Scotia to the Bahamas (Leatherwood et al., 1976). It is suggested that these whales are pelagic due to their infrequent stranding record. It is believed that True's beaked whales feed on squid as well as a variety of fish. As with other *Mesoplodon* spp., little is known about their life history.

Sowerby's beaked whales (*Mesoplodon bidens*) are known only from temperate to subarctic waters of the North Atlantic, and data suggest that they are more common in European than American waters (Leatherwood and Reeves, 1983). As with other *Mesoplodon* spp., little is known of their life history (Blaylock et al., 1995).

Cuvier's beaked whales (*Ziphius cavirostris*) range from Massachusetts to the West Indies, including waters of the Gulf of Mexico. Stock structure in the northwestern Atlantic is unknown (Blaylock et al., 1995). As with other beaked whales, it is believed that this species inhabits pelagic waters and exhibits a wide distribution. Migration to higher latitudes during summer has been suggested. This species feeds primarily on squid and deep water fish, but is also known to eat crab and starfish. No marked breeding season is evident. It is believed that calving occurs year-round. Cuvier's beaked whales form family groups of about 15 individuals. Little is known about the life history of this species. Sightings from CETAP (1982) surveys indicate the presence of Cuvier's beaked whales over the shelf break throughout the middle Atlantic region, with highest sightings recorded for late spring and summer.

Family Kogidae. The pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia simus*) appear to be distributed worldwide in temperate to tropical waters along the continental shelf edge and continental slope (Blaylock et al., 1995). As in the case of beaked whales, pygmy sperm whales and dwarf sperm whales are difficult to distinguish and are typically categorized as *Kogia* spp. There is no information on Atlantic stock differentiation and population size for these species (Blaylock et al., 1995). However, results cited by Hansen and Blaylock (1994) for a 1992 survey in the South Atlantic indicated a *Kogia* spp. population (i.e., *K. breviceps*, and dwarf sperm whales [*K. simus*]) of 420 individuals. Estimates of abundance were derived from 1992 winter observations using line-transect techniques between Cape Hatteras, North Carolina and Miami, Florida. *Kogia* are rarely seen alive at sea, but they are among the most frequently stranded small whales in some areas (Jefferson et al., 1993), including the southeastern U.S.

Family Stenidae. The family Stenidae includes the rough-toothed dolphin (*Steno bredanensis*). This species is distributed worldwide in tropical to warm temperate waters (Blaylock et al., 1995). Within the western Atlantic they range from Virginia and North Carolina to northeastern South America, including eastern and northwestern Gulf of Mexico waters (Leatherwood and Reeves, 1983). This species is pelagic and usually found seaward of the continental slope edge. Little is known about the life history of this species and no information exists on stock differentiation and population levels in the Atlantic (Blaylock et al., 1995).

Family Delphinidae. The family Delphinidae is taxonomically diverse and includes dolphins, killer whales, false killer whales, pygmy killer whales, Risso's dolphins (or grampus), short-finned pilot whales, and melon-headed whales.

Spinner dolphins (*Stenella longirostris*) range from North Carolina to southern Brazil, including Gulf of Mexico waters. Though presumably an offshore, deep-water species, they occur in both oceanic and coastal tropical waters (Blaylock et al., 1995). Two reproductive peaks in spring and fall have been suggested. Stock structure and population estimates of spinner dolphins in the western North Atlantic is unknown (Blaylock et al., 1995).

Atlantic spotted dolphins (*Stenella frontalis*) range from New Jersey to Venezuela, including waters of the Gulf of Mexico. This species is found in warm temperate and tropical waters. The Atlantic spotted dolphin inhabits the continental shelf and slope, though southern populations occasionally come into shallow coastal waters. Favored prey include herrings, anchovies, and carangid fish. Mating has been observed in July, with calves born offshore. Atlantic spotted dolphins often occur in groups of up to 50 individuals. Stock structure in the western North Atlantic is unknown. The minimum population estimate of 4,896 individuals was determined by the NMFS (in Blaylock et al., 1995).

Striped dolphins (*Stenella coeruleoalba*) range from Nova Scotia to the Lesser Antilles, including the Gulf of Mexico. These dolphins are distributed worldwide in temperate and tropical waters. This species is considered to be found along the continental slope from the Gulf of Mexico to Georges Bank. Migratory patterns are uncertain. There is no information on stock differentiation and population size in the Atlantic (Blaylock et al., 1995).

Pantropical spotted dolphins (*Stenella attenuata*) range from Massachusetts to the Lesser Antilles, including waters of the eastern Gulf of Mexico. They are distributed worldwide in subtropical and tropical oceans. They appear to prefer waters of the continental slope (Blaylock et al., 1995). It is believed that this species feeds on squid, fish, and shrimp. This species is often found in association with schools of tuna. Pantropical spotted dolphins occur in groups of 5 to 30 individuals. Little is known about the life history of this species and no information exists on stock differentiation and current population estimates for the Atlantic population (Blaylock et al., 1995).

Clymene dolphins (*Stenella clymene*) are widely distributed in subtropical and tropical waters of the Atlantic where they occur in the same geographic areas as *S. longirostris.* It is believed that this species lives over the deeper waters off the continental shelf (Blaylock et al., 1995). Little is known about its life history, and data on stock differentiation and population estimates in the Atlantic are not available (Blaylock et al., 1995).

Common dolphins (*Delphinus delphis*) range from Newfoundland and Nova Scotia to northern South America. They are distributed in worldwide temperate, tropical, and subtropical offshore waters on the continental slope, shelf, and shelf edge (Blaylock et al., 1995). According to Kenney and Winn (1987), CETAP (1982) results indicated the temporal presence of saddleback dolphins off the northeast U.S. coast in fall and winter, a trend which is the reverse of that exhibited by *Stenella* spp. and most other cetacean taxa, indicative of possible resource partitioning. The species is less common south of Cape Hatteras (Blaylock et al., 1995). Kenney and Winn (1987) also noted the possible co-occurrence of common dolphins with Atlantic spotted dolphins (*Stenella frontalis*). Common dolphins feed on epipelagic and mesopelagic fish, squid, and demersal fish

(Kenney and Winn, 1987). Breeding is seasonal. Gestation lasts 10 to 11 months, with calves born in spring and fall. The minimum population estimate of 3,321 individuals was determined by the NMFS (in Blaylock et al., 1995).

Fraser's dolphins (*Lagenodelphis hosei*) are distributed worldwide in tropical waters. This species appears to be largely oceanic, with preferred prey including shrimp, fish, and squid. Fraser's dolphins are found in groups of up to 500 individuals. Little is known about the life history of this species. There is no information on stock differentiation and population size in the Atlantic (Blaylock et al., 1995).

Atlantic white-sided dolphins (*Lagenorhynchus acutus*) are found in temperate and sub-polar waters of the North Atlantic, and appear to prefer deep waters of the outer continental shelf and slope. This species ranges from central West Greenland to Chesapeake Bay. Population estimates from aerial surveys between Cape Hatteras, North Carolina and Nova Scotia (Canada) from 1978 to 1982 (CETAP, 1982) was 28,600 individuals. Minimum population estimates based on 1991-92 shipboard survey abundance data was 12,540 individuals (Blaylock et al., 1995).

Bottlenose dolphins (*Tursiops truncatus*) in the western Atlantic range from Nova Scotia to Venezuela, as well as the waters of the Gulf of Mexico (Hansen and Blaylock, 1994). This species is distributed worldwide in temperate and tropical inshore waters. Middle Atlantic populations are represented by a hematologically and morphologically distinct offshore stock and coastal stock (Duffield et al., 1983; Duffield, 1986; Hersh and Duffield, 1990; Hansen and Blaylock, 1994). Aerial survey results reported by CETAP (1982) and Kenney (1990) indicated the offshore stock extends along the entire shelf break from Georges Bank to Cape Hatteras during spring and summer. During fall, this distribution compressed towards the south, with fewer sightings in winter. According to Kenney (1990), the offshore stock is concentrated along the shelf break, extending beyond the shelf edge in lower concentrations. Peak average estimated abundance for the offshore stock occurred during fall and was estimated to be 7,696 individuals (Hansen and Blaylock, 1994). No abundance estimates are available for the offshore stock south of Cape Hatteras (Blaylock et al., 1995). Recent research has indicated that there are a variety of stock structures possible within the coastal Atlantic bottlenose dolphin population both north and south of Cape Hatteras. Blaylock and Hoggard (1994), reporting results from the Southeast Cetacean Aerial Survey (SECAS) study (i.e., continental shelf waters; Cape Hatteras, North Carolina to mid-Florida; Gulf of Mexico waters), developed abundance estimates for the shallow, warm water Atlantic bottlenose dolphin ecotype. The offshore distribution of coastal bottlenose dolphins south of Cape Hatteras has not been described. Blaylock and Hoggard (1994) noted, however, the possibility for coexistence of the coastal and offshore stocks inhabiting the edge of the outer continental shelf and slope waters south of Cape Hatteras. Bottlenose dolphins feed on shrimp and fish. Mating and calving occur from February to May in Florida waters. The calving interval is 2 to 3 years. They are found in groups of up to several hundred individuals with group sizes increasing with distance from shore.

Harbor porpoises (*Phocoena phocoena*) are found in cool temperate and subpolar waters of the Northern Hemisphere. They are typically found in shallow water, most often nearshore, although occasionally travel over deeper offshore waters (Jefferson et al., 1993). During summer, harbor porpoises are concentrated in Canada and the

northern Gulf of Maine. During fall and spring, they are widely distributed from Maine to North Carolina (Blaylock et al., 1995). The minimum population estimate was 40,345 individuals (Blaylock et al., 1995).

Killer whales (*Orcinus orca*) are characterized as uncommon or rare in waters of the western Atlantic. They are distributed from the Arctic pack ice to the Lesser Antilles, including waters of the Gulf of Mexico. Migration is thought to occur in association with changes in food abundance. Killer whales feed on squid, fish, sea turtles, seabirds, and other marine mammals. It is believed that mating occurs throughout the year, with gestation requiring about 1 year. Killer whales are found in groups ranging from a few to 25 to 30 individuals, where social structure and territoriality may be important. Stock definition and population estimates in the Atlantic are unknown (Blaylock et al., 1995).

False killer whales (*Pseudorca crassidens*) range from Maryland to Venezuela, including Gulf of Mexico waters. This species is distributed worldwide in tropical and temperate waters. False killer whales are generally considered to be oceanic but individuals have been observed in cool, nearshore waters. This species feeds on squid and fish. It is believed that mating occurs year round, with a gestation period of about 15 months. False killer whales are found in large groups composed of smaller family groups of 4 to 6 individuals. Stock definition and population estimates in the Atlantic are unknown (Blaylock et al., 1995).

Pygmy killer whales (*Feresa attenuata*) range from North Carolina to the Lesser Antilles, as well as Gulf of Mexico waters. This species is distributed worldwide in tropical and warm temperate waters. Preferred prey includes small fish. Nocturnal feeding has been noted for this species. It is believed that calving occurs in spring. This species is typically found in groups of 10 individuals. Little is known about the life history of this species. Stock definition and population estimates in the Atlantic are unknown (Blaylock et al., 1995).

Risso's dolphins (*Grampus griseus*) range from eastern Newfoundland to the Lesser Antilles and Gulf of Mexico. This species is distributed worldwide in tropical to temperate waters. It is believed that Risso's dolphins undergo north-south, summer-winter migrations. Off the northeast U.S. coast, Risso's dolphins are distributed along the shelf edge from Cape Hatteras northward to Georges Bank during spring, summer, and fall (CETAP, 1982; Payne et al., 1984). In winter, this species ranges further offshore (Blaylock et al., 1995). Typically, this species occupies the continental shelf edge year-round. This species feeds mainly on squid. Risso's dolphins are found in groups of 3 to 30 individuals, although groups of up to several hundred individuals have been reported. Total numbers of Risso's dolphins off the eastern U.S. coast are unknown. CETAP (1982) survey results indicated a population estimate of 4,980 individuals. Current data are insufficient to determine stock differentiation and population trends in the Atlantic. This species is considered a "strategic stock" under the Marine Mammal Protection Act (Blaylock et al., 1995).

Short-finned pilot whales (*Globicephala macrorhynchus*) occur in the western Atlantic from New Jersey to Venezuela, as well as in waters of the Gulf of Mexico. This species is found worldwide in warm temperate and tropical waters. Sightings of pilot whales typically occur seaward of the continental shelf edge and within waters of the Gulf

Stream (Blaylock et al., 1995). Little is known about migration. Preferred prey items include squid and fish. It is believed that this species has an extended breeding and calving season in warm waters. Short-finned pilot whales have been observed chasing and feeding on schools of tuna. There is no information on stock differentiation for the Atlantic population. Estimated abundance of pilot whales between Miami, Florida and Cape Hatteras, North Carolina, derived from a 1992 shipboard survey, was 749 individuals (Blaylock et al., 1995).

Long-finned pilot whales (*Globicephala melaena*) are distributed from Iceland to North Carolina. They are commonly found in both oceanic and certain coastal waters of the North Atlantic (Jefferson et al., 1993). The stock structure of the North Atlantic population is currently unknown (Blaylock et al., 1995).

Melon-headed whales (*Peponocephala electra*) are distributed worldwide in tropical to sub-tropical waters (Blaylock et al., 1995). Melon-headed whales are highly social, and are known to occur in pods of 100 to 500 animals. They are often seen swimming with dolphin species and are known to feed on squid and small fish. There is some evidence to indicate a calving peak in July and August, but this evidence is inconclusive (Jefferson et al., 1993). There is no information on stock differentiation and population estimates in the Atlantic (Blaylock et al., 1995).

B.1.2.3 Pinnipeds

Harbor seals (*Phoca vitulina*) are widely distributed from temperate to polar regions of the Northern Hemisphere. Along the eastern U.S. they are found from the Canadian Arctic to the mid-Atlantic (Jefferson et al., 1993). At sea, they are mainly found in coastal waters of the continental shelf and slope.

B.1.3 Description of 1995 Aerial Surveys

Between April and September 1995, six aerial surveys of the Mayport and Norfolk areas were completed to estimate the density of marine mammals and sea turtles. Survey data were used to support development of the DEIS and associated permit requests. Details of the surveys are outlined in the following sections. Survey results are presented in Department of the Navy (1995b).

B.1.3.1 Survey Locations

The two areas lie along the 152 m (500 ft) depth contour within a 185 km (100 nmi) radius of naval facilities at Mayport, Florida and Norfolk, Virginia (**Figures B-2** and **B-3**). Along the Atlantic coast in these areas, this bathymetric contour represents the continental shelf edge (Abernathy, 1989).

Within the Norfolk survey area, the northern limit was established just south of the proposed Norfolk Canyon National Marine Sanctuary [National Oceanic and Atmospheric Administration (NOAA), 1990]. The sanctuary and the area to the north were excluded due to environmental concerns with the sanctuary waters and the presence of a number of shipwrecks. The survey area thus extended from latitude

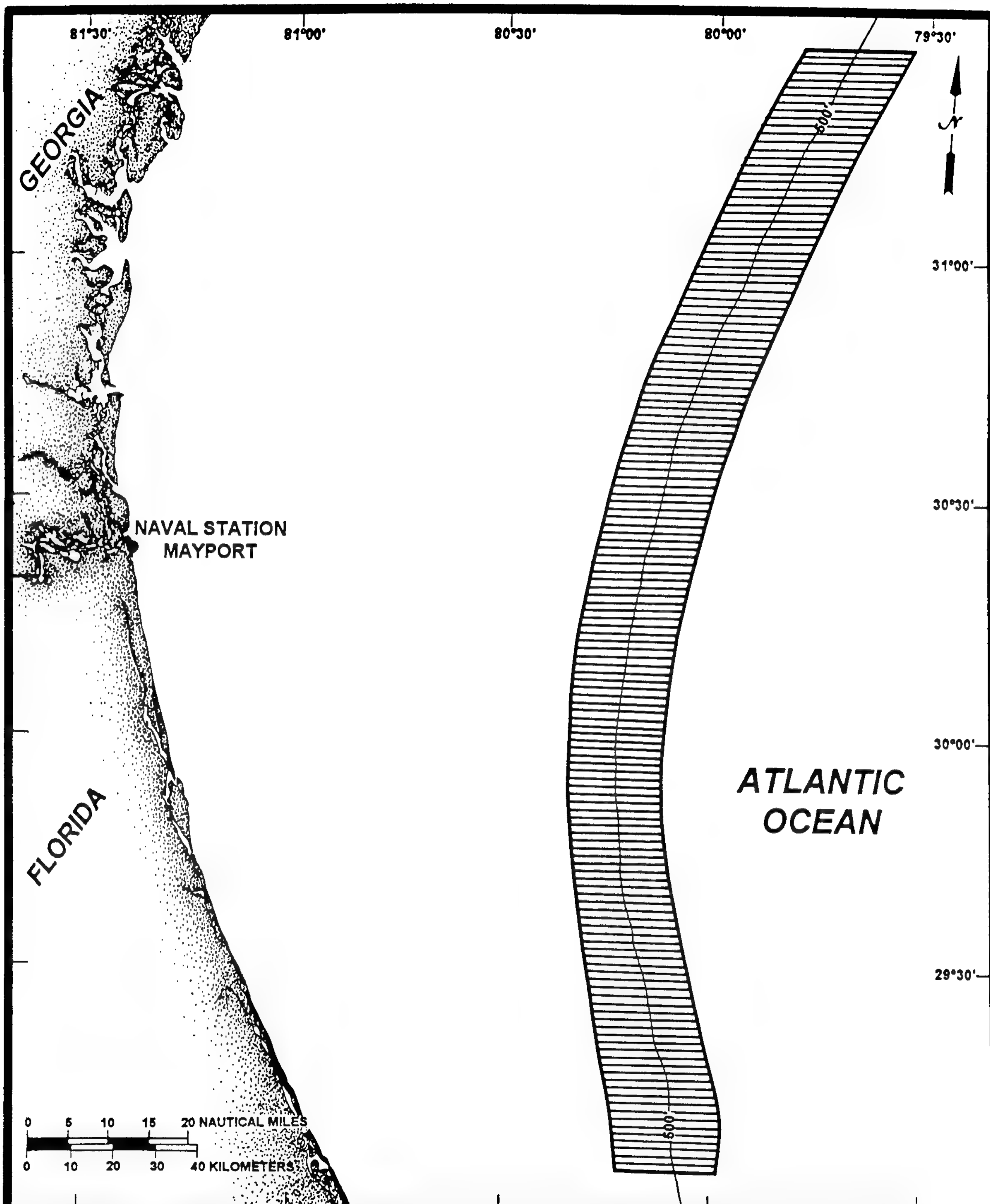

Figure B-2. Location of Mayport aerial survey area showing transects relative to the 152 m (500 ft) depth contour.

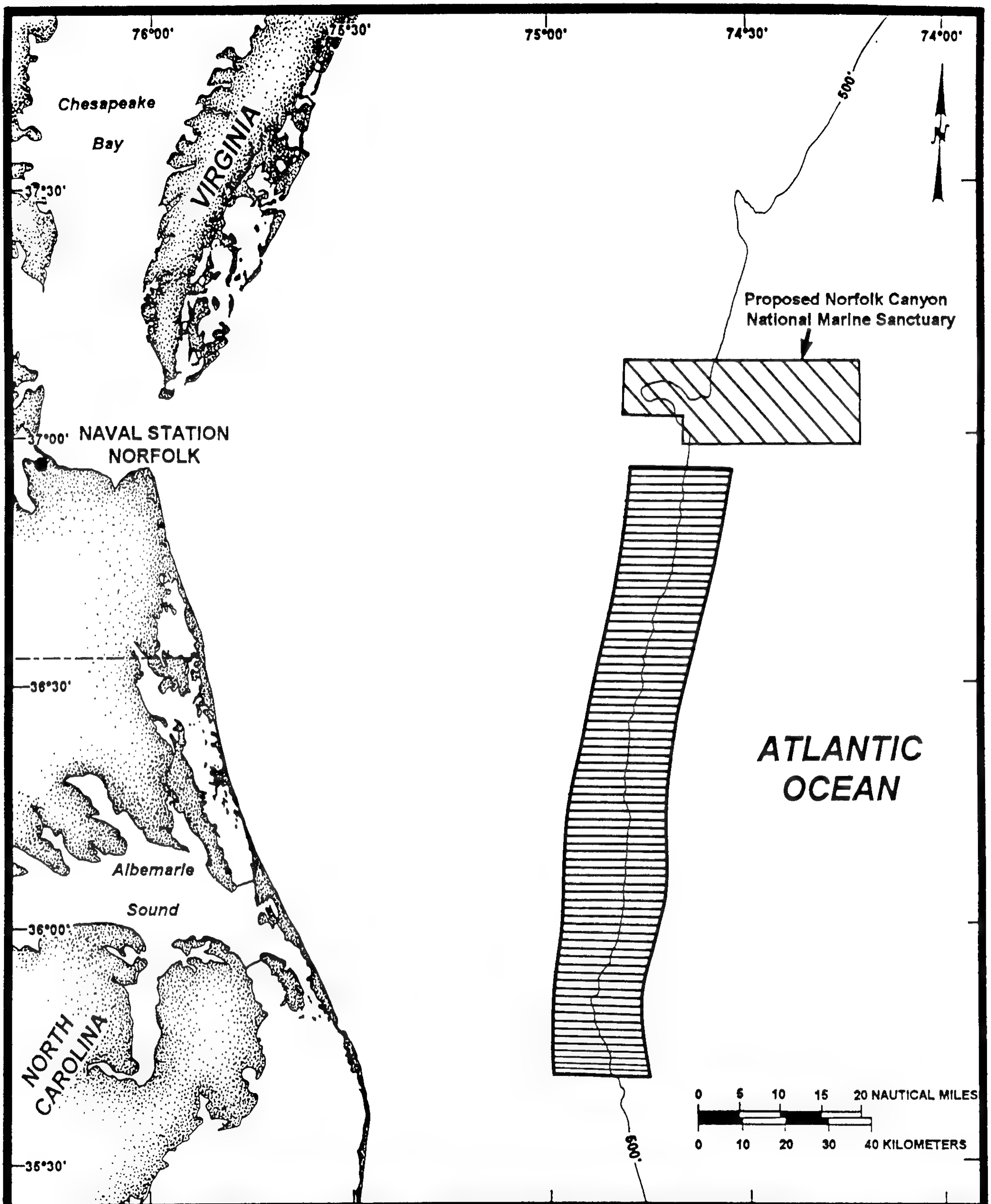

Figure B-3. Location of Norfolk aerial survey area showing transects relative to the 152 m (500 ft) depth contour.

36°56.00'N to 35°41.00'N. All survey flights were staged from the Elizabeth City-Pasquotank County Municipal Airport, Elizabeth City, North Carolina.

The Mayport survey area extended from latitude 31°25.00'N to 29°01.00'N. All survey flights were staged from the Glynco-Taj Jetport in Brunswick, Georgia.

B.1.3.2 Survey Methods

Standard line transect aerial surveying methods for marine mammals and sea turtles, as developed and approved by the NMFS, were adopted for the surveys (Blaylock, 1994). These methods use observers on both sides of the survey aircraft who, along predetermined transect lines, scan a swath of sea surface which is limited only by the effective angle of view from the aircraft's viewing port or window, and sea state. The total area viewed during each survey was 2,948 km^2 (858 nmi^2) at the Mayport area and 1,470 km^2 (428 nmi^2) at the Norfolk area.

Survey transects within the two survey areas were set up from east to west and with 1.85 km (1 nmi) line spacing, using current NOAA bathymetric maps and navigation charts. Based upon the limitations of fuel which could be carried by the survey aircraft, transit and per transect flight time, number of transects per survey area, estimates of time allotted for orbiting groups of animals, and expected observer fatigue, it was calculated that approximately 25 transects could be completed in one day. Therefore, the Norfolk survey area required three days for completion and the Mayport survey area six days for completion.

A Cessna C-337G Skymaster twin-engine aircraft, provided by Aero-Marine Surveys, Inc. (New London, Connecticut), was used as the survey platform (**Figure B-4**). A portable computer was interfaced with the onboard LORAN C receiver to collect navigation and supplemental survey data at one minute intervals while on transect. Navigation data included aircraft location (latitude and longitude), speed, course, and altitude. Supplemental data included survey area, transect number, estimates of weather conditions, sea state, and water clarity, and the extent of visual hindrance resulting from sunlight glare on the sea surface. An onboard radiation thermometer was also interfaced with the onboard computer to collect sea surface temperature data at each navigation fix (Thompson and Shoop, 1983; Schroeder and Thompson, 1987). The LORAN receiver was calibrated against an onboard Global Positioning System (GPS) receiver prior to each survey flight. This calibration was done at the same position on the airport taxiway each day. Similarly, the onboard radiation thermometer was calibrated using water tanks of known temperatures subsequent to each survey flight.

According to NMFS, the standard altitudes for marine mammal and sea turtle surveys are 229 m (750 ft) and 152 m (500 ft), respectively (Hoggard, 1994; Mullin, 1994). It was suggested that the surveys be conducted at an altitude of 198 m (650 ft), an altitude which is considered by NMFS as the optimum compromise when conducting simultaneous surveys for both marine mammals and sea turtles. However, based on further discussions between the Navy and NMFS, it was decided that conducting the combined aerial survey at an altitude of 229m (750 ft) was acceptable. Therefore, all transects were surveyed at an altitude of 229 m (750 ft) and a speed of 127 mi/h (110 kn).

MISSION DATA (TYPICAL)

FLIGHT CREW: 1
SCIENTIFIC PARTY: 3
CRUISE SPEED: 130 KNOTS
ENDURANCE: 7.8 HOURS
RESERVES (VFR,DAY): 0.7 HOURS
TRACK LINE MILEAGE: 1,014 NAUTICAL MILES

MANUFACTURER: CESSNA
REGISTRATION: N700AM
TYPE: C-337G
ENGINE (2 EACH): CONT. IO-360-G
SERVICE CEILING: 18,000 FEET

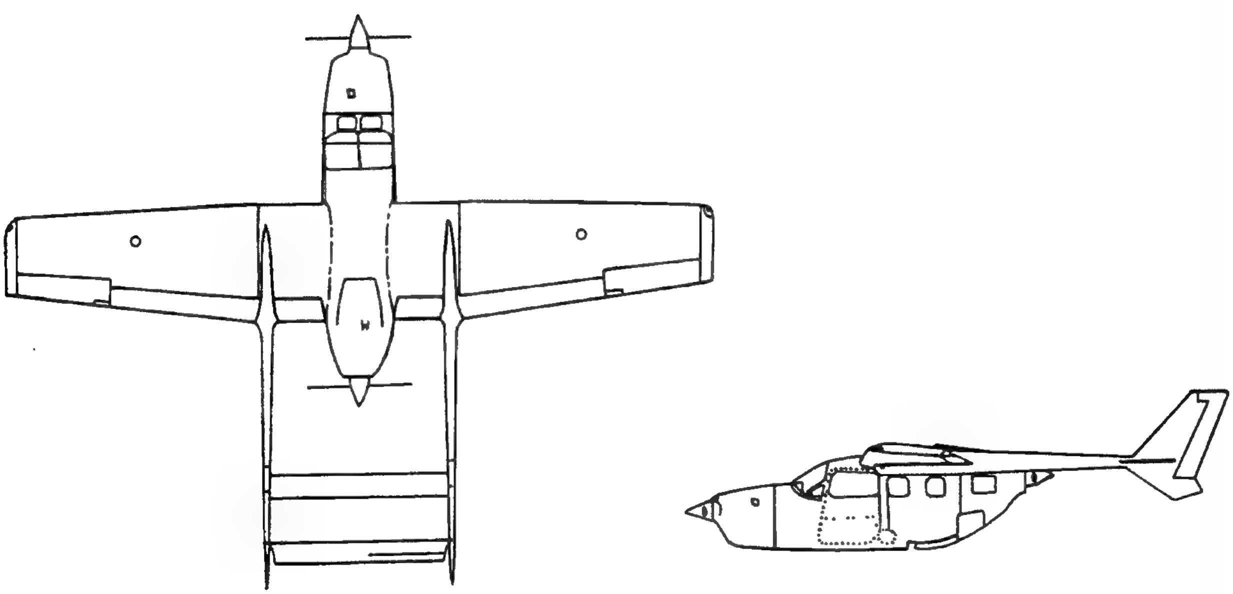

Figure B-4. Cessna multi-engine survey aircraft specifications.

Surveys were generally conducted between 0800 and 1500 h for maximum light penetration below the sea surface. Two observers were seated in the rear of the aircraft, using the forward and second side windows for scanning. The data logger sat opposite the pilot. This method is commonly used by NMFS during aerial surveys (NMFS, 1991, 1992). Along each survey transect, the observers continually scanned the sea surface in a roughly circular pattern. This strategy allowed for observation of distant sea surface disturbances caused by marine mammals, approaching animals, and detailed close up views abeam and abaft the beam of the aircraft. The effective sighting angles from the aircraft while on transect are shown in **Figure B-5**. Blind areas below the aircraft are shown as shaded voids. The effective vertical sighting angles, or visual transect swath, was approximately 45 to 65°.

The horizontal sighting angle was approximately 90°, or 45° forward and aft of the beam. The vertical and horizontal width of the transect swath varied inversely with local sea state conditions and sunlight glare; that is, observers tended to narrow their scan when sea conditions increased or during conditions of glare hindrance. As shown in **Figure B-5**, a substantial visual overlap between transects was attained during periods of low sea state and glare.

When an individual animal or group of animals was sighted, the observer would determine the perpendicular sighting distance of the sighting using a hand-held inclinometer (Suunto Model PM-5) (Musick et al., 1987; Barlow et al., 1988; Forney et al., 1991; Blaylock and Hoggard, 1994). Using the aircraft's intercom, the observer would then request a navigation fix, state animal type and approximate group number, and request, if deemed necessary for the determination of species identification(s), that the aircraft break transect and circle (i.e., orbit) for a closer examination. The pilot would, in the case of nonendangered marine mammals, lower altitude to approximately 183 m (600 ft) and return to the sighting fix. The marine mammal group in question was orbited until the identification of species was made and an accurate number of individuals assessed. Endangered marine mammals were, if possible, identified while on transect, or circled once at the survey altitude of 229 m (750 ft). Observations of individual or group behavior were also made during this time. Data relating to each sighting, along with exact location of the aircraft, transect number, observer, and location of the sighting in relation to the aircraft, were recorded onto data sheets by the data logger. After identification, the aircraft returned to the previous break position on the transect line and continued to survey.

Aerial surveys were usually conducted at a Beaufort sea state of 3 or less, which allows for the most accurate sighting and identification of individual marine mammals or sea turtles. Surveys were typically suspended when the Beaufort sea state exceeded 3 during the transit to the survey area or during the course of the survey.

B.1.3.3 Permits

All aerial surveys were conducted under the appropriate permits and authorizations or with specific permission from NMFS.

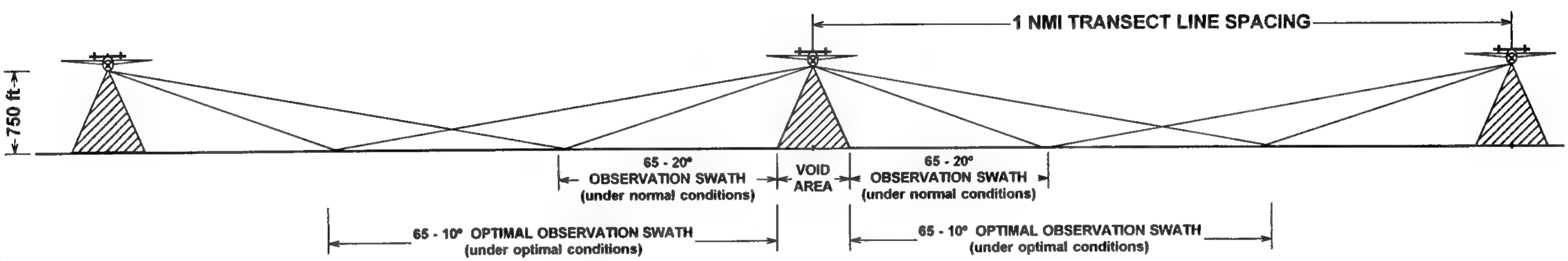

Figure B-5. Transect observation swaths from survey aircraft under normal and optimal sighting conditions. Distances to scale.

B.1.4 Adjustment of Marine Mammal Densities for Submerged and Undetected Individuals

Six aerial surveys were conducted at the Mayport and Norfolk areas during 1995 to estimate densities of marine mammals, as described above. Densities calculated from these aerial observations do not take into account submerged individuals or those that may have been on the surface but undetected. Therefore, adjusted densities were developed for each species seen during the surveys. Adjusted densities were calculated as follows:

$$D_{adj} = D_{obs}/P$$

where D_{adj} is the adjusted density, D_{obs} is the observed density, and P is the proportion of the total population believed to be detected by the aerial surveys. P was calculated as follows:

$$P = S_t \times ADP$$

where S_t is the probability of an animal being on the surface at any given time, and ADP is the aerial detection probability (the probability that an individual on the surface would be detected from the air).

Probabilities of being on the surface (S_t) were estimated by reviewing literature on the dive times of cetaceans and by consulting with marine mammal experts. All of the values for individual species were either 0.1 or 0.2 (i.e., the animals spend most of the time submerged). Aerial detection probabilities (ADP) were estimated based on animal length and herding tendencies. It was assumed that larger animals and those that tend to occur in groups would have a higher probability of detection. Each species was scored using the following scales:

Length
0 = <1 m (<3 ft)
1 = 1-1.5 m (3-5 ft)
2 = 1.8-3 m (6-10 ft)
3 = 3.4-5.5 m (11-18 ft)
4 = 5.8-7.6 m (19-25 ft)
5 = >7.6 m (>25 ft)

Herding
0 = Not likely
1 = Somewhat likely
2 = Likely
3 = Very likely
4 = Highly likely

For each species, the length and herding scores were summed and a corresponding ADP was assigned as follows:

Sum of Length and Herding Scores	Aerial Detection Probability (ADP)
0	0.1
1	0.3
2	0.5
3-4	0.7
5-9	0.9

Table B-1 summarizes the results of these calculations. The table shows mean densities for the six-month survey period (April through September 1995). Because there would be no shock testing in April at Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April). The estimated proportion of the population detected (P) ranged from 0.09 to 0.18. Therefore, adjusted densities were estimated to be 6 to 11 times higher than observed densities.

B.1.5 Mitigation Effectiveness Calculations for Marine Mammals

The Marine Mammal and Sea Turtle Protection/Mitigation Plan (see Section 5.0 of the DEIS) includes the use of aerial and shipboard observers and passive acoustic surveys to detect marine mammals within the safety range prior to detonation. For impact analysis, it was necessary to estimate mitigation effectiveness, i.e., the probability of detecting an animal if present.

Mitigation effectiveness was estimated separately for each component (aerial monitoring, surface monitoring, and passive acoustic monitoring), then combined. The approach to estimating mitigation effectiveness was based on previous environmental assessments (Department of the Navy, 1993, 1994) and reviewed by marine mammal experts.

B.1.5.1 Aerial Monitoring

For aerial monitoring, mitigation effectiveness (ME) was calculated as follows:

$$ME_{aerial} = ADP \times S_{aerial}$$

where ADP is aerial detection probability as defined previously, and S_{aerial} is the probability of an animal being on the surface at least once during aerial monitoring. S_{aerial} is not the same as S_t, which was used to adjust 1995 aerial survey data as discussed above. Unlike the 1995 surveys, aerial monitoring would include three complete passes over the site: one pass 2.5 hours prior to detonation, and two passes (line transects and concentric circles) within 1 hour prior to detonation (see Section 5.0). Therefore, the probability of being on the surface during at least one pass is higher than for the 1995 aerial surveys, which consisted of a single pass over each transect.

Using the S_t values from Table B-1 to represent the probability of an animal being on the surface at any given time, the probability of an animal being on the surface during at least one of three passes can be estimated using binomial theory (Winkler and Hays, 1975):

$$P \text{ (on surface at least once in three trials)} = 1 - (1 - S_t)^3$$

For S_t = 0.2 (the most common value in Table B-1), this yields a value of 0.49 for S_{aerial}. In other words, if there is a 0.2 probability of being on the surface during a single pass, there is a 0.49 probability of being on the surface at least once during three passes.

This method assumes that the three passes during aerial monitoring would be independent sampling events. For short-diving species such as dolphins, small toothed

Table B-1. Adjustment of 1995 aerial survey data to account for submerged and undetected marine mammals.

Species	Probability of Being on Surface (S_t)	Aerial Detection Calculations			Proportion of Population Detected ($P = S_t \times ADP$)	Mayport Densities[a] All Six Surveys (Individuals/100 km^2)		Mayport Densities[a] Excluding April (Individuals/100 km^2)		Norfolk Densities[a] All Six Surveys (Individuals/100 km^2)	
		Length Score	Herding Score	Aerial Detection Probability (ADP)		Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)
BALEEN WHALES											
Fin whale (E)	0.2	5	2	0.9	0.18	0	0	0	0	0.52	2.90
Humpback whale (E)	0.2	5	3	0.9	0.18	0	0	0	0	0.01	0.06
Minke whale	0.1	5	1	0.9	0.09	0	0	0	0	0.02	0.25
Sei whale (E)	0.2	5	2	0.9	0.18	0	0	0	0	0.02	0.13
Sei/Bryde's whale	0.2	5	2	0.9	0.18	0	0	0	0	0.01	0.06
Unidentified *Balaenoptera* spp.	0.2[b]	5	NA	0.9[b]	0.18	0	0	0	0	0.14	0.76
Unidentified large whale	0.2[b]	5	NA	0.9[b]	0.18	0	0	0	0	0.05	0.25
TOOTHED WHALES AND DOLPHINS											
Atlantic spotted dolphin	0.2	2	4	0.9	0.18	0.88	4.90	0.52	2.90	9.34	51.90
Bottlenose dolphin	0.2	2	3	0.9	0.18	1.39	7.70	0.53	2.94	5.83	32.38
Bottlenose/Atlantic spotted dolphin	0.2	2	3	0.9	0.18	0.15	0.82	0.18	0.98	0.73	4.03
Clymene/spinner/striped dolphin	0.2	2	4	0.9	0.18	0.25	1.38	0.13	0.72	2.78	15.43
Common dolphin	0.2	2	4	0.9	0.18	0	0	0	0	3.51	19.53
Cuvier's beaked whale	0.1	4	2	0.9	0.09	0	0	0	0	0.02	0.25
Pantropical spotted dolphin	0.2	2	4	0.9	0.18	2.19	12.15	1.55	8.63	4.93	27.40
Pilot whale[c]	0.2	3	3	0.9	0.18	0	0	0	0	15.60	86.67

Table B-1. (continued).

Species	Probability of Being on Surface (S_t)	Aerial Detection Calculations			Proportion of Population Detected ($P = S_t \times ADP$)	Mayport Densities[a] All Six Surveys (Individuals/100 km^2)		Mayport Densities[a] Excluding April (Individuals/100 km^2)		Norfolk Densities[a] All Six Surveys (Individuals/100 km^2)	
		Length Score	Herding Score	Aerial Detection Probability (ADP)		Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)
Risso's dolphin	0.2	3	3	0.9	0.18	1.10	6.12	1.19	6.60	1.35	7.50
Sperm whale (E)	0.1	5	2	0.9	0.09	0.01	0.13	0.01	0.15	0.05	0.50
Spinner dolphin	0.2	2	4	0.9	0.18	0.28	1.57	0.34	1.88	0.70	3.91
Striped dolphin	0.2	2	4	0.9	0.18	0	0	0	0	0.27	1.51
Unidentified dolphin	0.2[b]	NA	NA	0.9[b]	0.18	1.12	6.22	1.28	7.09	4.38	24.31
Unidentified small whale	0.2[b]	NA	NA	0.9[b]	0.18	0	0	0	0	0.06	0.32
TOTAL MARINE MAMMALS						**7.37**	**40.99**	**5.73**	**31.89**	**50.32**	**280.05**

(E) = endangered species. NA = not applicable.

[a] Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data. Some values may differ slightly from those one could calculate using the tabulated numbers.

[b] Composite values were assigned for unidentified species.

[c] The two species of pilot whales in the western Atlantic, the long-finned pilot whale (*Globicephala melaena*) and short-finned pilot whale (*G. macrorhynchus*), are difficult to differentiate in the field and have been combined in this analysis.

whales, and many baleen whales, this is a reasonable assumption because individual animals could dive and surface several times between aerial passes. For large, deep-diving species (e.g., minke whale, sperm whale, and possibly Cuvier's beaked whale), an individual animal could be submerged on the same dive during successive passes, but the assumption would still be valid when applied to the population as a whole as long as dives of individual animals are independent. Because these whales have relatively low herding scores (Table B-1), this is a reasonable assumption.

Table B-2 shows the ADP and S_{aerial} values for each species. The product of these two values is the aerial mitigation effectiveness (ME_{aerial}) for each species.

B.1.5.2 Surface Monitoring

For aerial monitoring, mitigation effectiveness was calculated as:

$$ME_{surface} = SDP \times S_{surface}$$

where $S_{surface}$ is the probability of an animal being on the surface at least once during surface monitoring, and SDP is the probability that a species would be detected by surface observers, if present. The method for estimating SDP was similar to the approach described above for ADP, except that visibility enhancements such as leaping, blowing, spinning, and bow wave riding were also considered. Each species was scored using the following scales:

Length	**Herding**	**Visibility Enhancements**
0 = <1 m (<3 ft)	0 = Not likely	0 = Very Poor
1 = 1-1.5 m (3-5 ft)	1 = Somewhat likely	1 = Poor
2 = 1.8-3 m (6-10 ft)	2 = Likely	2 = Low
3 = 3.4-5.5 m (11-18 ft)	3 = Very likely	3 = Average
4 = 5.8-7.6 m (19-25 ft)	4 = Highly likely	4 = Significant
5 = >7.6 m (>25 ft)		5 = Conspicuous

For each species, the length, herding, and visibility enhancement scores were summed and a corresponding SDP was assigned as follows:

Sum of Length, Herding, and Visibility Scores	**Surface Detection Probability (SDP)**
0	0
1	0.1
2	0.3
3	0.5
4-5	0.7
6-14	0.9

The other term in the equation, $S_{surface}$, is not the same as S_t, which was used to adjust 1995 aerial survey data. Unlike the 1995 aerial surveys, surface monitoring would include continuous observations during at least 2.5 hours prior to detonation (see

Table B-2. Estimated mitigation effectiveness of aerial monitoring for marine mammals.

Species	Length Score	Herding Score	Aerial Detection Probability (ADP)[a]	Probability of Being on Surface (S_{aerial})	Aerial Mitigation Effectiveness (ME_{aerial})[b]
BALEEN WHALES					
Fin whale (E)	5	2	0.9	0.49	0.44
Humpback whale (E)	5	3	0.9	0.49	0.44
Minke whale	5	1	0.9	0.27	0.24
Sei whale (E)	5	2	0.9	0.49	0.44
Sei/Bryde's whale	5	2	0.9	0.49	0.44
Unidentified *Balaenoptera* spp.	5	2	0.9	0.49	0.44
Unidentified large whale	NA	NA	0.9[c]	0.49	0.44
TOOTHED WHALES AND DOLPHINS					
Atlantic spotted dolphin	2	4	0.9	0.49	0.44
Bottlenose dolphin	2	3	0.9	0.49	0.44
Bottlenose/Atl. spotted dolphin	2	3	0.9	0.49	0.44
Clymene/spinner/striped dolphin	2	4	0.9	0.49	0.44
Common dolphin	2	4	0.9	0.49	0.44
Cuvier's beaked whale	4	2	0.9	0.27	0.24
Pantropical spotted dolphin	2	4	0.9	0.49	0.44
Pilot whale	3	3	0.9	0.49	0.44
Risso's dolphin	3	3	0.9	0.49	0.44
Sperm whale (E)	5	2	0.9	0.27	0.24
Spinner dolphin	2	4	0.9	0.49	0.44
Striped dolphin	2	4	0.9	0.49	0.44
Unidentified dolphin	NA	NA	0.9[c]	0.49	0.44
Unidentified small whale	NA	NA	0.9[c]	0.49	0.44

(E) = endangered species. NA = not applicable.

a ADP depends on sum of length and herding scores (see text).
b $ME_{aerial} = ADP \times S_{aerial}$.
c Composite values were assigned for unidentified species.

Section 5.0). Depending on weather conditions, the observers could detect marine mammals out to 4 to 6 nmi from the detonation point. $S_{surface}$ therefore refers to the probability that an animal would be on the surface within 4 to 6 nmi of the detonation point at least once during the 2.5 hours preceding detonation. In order to be not detectable by surface observers, an animal would have to be submerged during the entire time it was present in the area.

Typical dive times for dolphins, small toothed whales, and many baleen whales are on the order of several minutes (Jefferson et al., 1993; Ridgway and Harrison, 1994; Tyack, 1996). It is reasonable to assume that if these animals were present in the area, they would probably be on the surface at least once during the 2.5 hours preceding detonation. Therefore, an $S_{surface}$ value of 0.95 was assigned to these animals.

Some species such as minke and sperm whales and possibly Cuvier's beaked whale can have longer dive times; dives of up to 2 hours have been reported for sperm whales (Jefferson et al., 1993). The probability of being on the surface at least once during 2.5 hours is obviously higher than the surface probability (S_t) listed in Table B-1. A conservative assumption is that $S_{surface}$ for these species would be no less than S_{aerial} defined above, which is based on three independent aerial passes rather than continuous surface observations. The following values were assigned:

- Dolphins and small toothed whales: $S_{surface} = 0.95$
- Baleen whales (except minke): $S_{surface} = 0.95$
- Minke, Cuvier's, sperm whale: $S_{surface} = S_{aerial} = 0.27$

Table B-3 shows the SDP and $S_{surface}$ values for each species. The product of these two values is the surface mitigation effectiveness ($ME_{surface}$) for each species.

B.1.5.3 Passive Acoustic Monitoring

The passive acoustic monitoring system described in Section 5.0 is capable of detecting any marine mammal sounds within the safety range. The following values were estimated for acoustic detection probability (Tyack, 1996):

- Sperm whales and *Stenella* (clymene, spinner, and striped dolphins) $ME_{acoustic} = 0.75$
- Other odontocetes except Cuvier's beaked whale: $ME_{acoustic} = 0.50$
- Baleen whales and Cuvier's beaked whale: $ME_{acoustic} = 0.25$

These estimates are based on the tendency of the animals to make detectable sounds. Sperm whales produce distinctive clicked vocalizations, or "codas" (Jefferson et al., 1993) and are considered very likely to be detected acoustically if present in the area (Tyack, 1996). As indicated by the herding scores in Table B-2, most of the dolphins are highly social, and the presence of a school would almost certainly be accompanied by whistles, clicks, and other detectable sounds.

Table B-3. Estimated mitigation effectiveness of surface monitoring for marine mammals.

Species	Length Score	Herding Score	Visibility Enhance-ments Score	Surface Detection Probability (SDP)[a]	Probability of Being on Surface ($S_{surface}$)	Surface Mitigation Effectiveness ($ME_{surface}$)[b]
BALEEN WHALES						
Fin whale (E)	5	2	3	0.9	0.95	0.855
Humpback whale (E)	5	3	5	0.9	0.95	0.855
Minke whale	5	1	2	0.9	0.27	0.24
Sei whale (E)	5	2	3	0.9	0.95	0.855
Sei/Bryde's whale	5	2	4	0.9	0.95	0.855
Unidentified *Balaenoptera* spp.	5	2	3	0.9	0.95	0.855
Unidentified large whale	5	NA	NA	0.9[c]	0.95[c]	0.855
TOOTHED WHALES AND DOLPHINS						
Atlantic spotted dolphin	2	4	3	0.9	0.95	0.855
Bottlenose dolphin	2	3	3	0.9	0.95	0.855
Bottlenose/Atl. spotted dolphin	2	3	3	0.9	0.95	0.855
Clymene/spinner/striped dolphin	2	4	3	0.9	0.95	0.855
Common dolphin	2	4	3	0.9	0.95	0.855
Cuvier's beaked whale	4	2	2	0.9	0.27	0.24
Pantropical spotted dolphin	2	4	3	0.9	0.95	0.855
Pilot whale	3	3	2	0.9	0.95	0.855
Risso's dolphin	3	3	3	0.9	0.95	0.855
Sperm whale (E)	5	2	4	0.9	0.27	0.24
Spinner dolphin	2	4	4	0.9	0.95	0.855
Striped dolphin	2	4	3	0.9	0.95	0.855
Unidentified dolphin	NA	NA	NA	0.9[c]	0.95	0.855
Unidentified small whale	NA	NA	NA	0.9[c]	0.95	0.855

(E) = endangered species. NA = not applicable.

[a] SDP depends on sum of length, herding, and visibility enhancements scores (see text).
[b] $ME_{surface}$ = SDP x $S_{surface}$.
[c] Composite values were assigned for unidentified species.

B.1.5.4 Combined Mitigation Effectiveness

Mitigation effectiveness for all three components (aerial, surface, and passive acoustic monitoring) would be greater than for any individual component. Aerial and surface monitoring would be expected to have the greatest overlap in detection, but it is difficult to estimate the extent of overlap. Therefore, it was conservatively assumed that overall visual mitigation effectiveness would be equal to the greater of the two (aerial or surface detection). In other words, the calculation assumes that there would be no gain by using the combination of aerial and surface observers.

$$ME_{visual} = \max (ME_{aerial}, ME_{surface})$$

Passive acoustic monitoring would improve overall mitigation effectiveness by detecting some proportion of the non-visually detected population ($1 - ME_{visual}$). Because acoustic monitoring is assumed to be independent of visual monitoring, the proportion detected would be equal to $ME_{acoustic}$, as defined above. Total mitigation effectiveness was therefore calculated as follows:

$$ME_{combined} = ME_{visual} + [ME_{acoustic} \times (1 - ME_{visual})]$$

For example, suppose 0.6 of the population would be detected aerially and 0.55 would be detected by surface observers. ME_{visual} would be the greater of the two, or 0.6. Therefore, 0.4 of the population would not be detected visually. Then suppose that passive acoustic monitoring detects 0.25 of the population, independent of whether the animals are visible to observers. Therefore, 0.25 of the "non-visible" animals would be detected acoustically. The additional proportion of the entire population detected acoustically would be 0.25 x 0.4 = 0.1. Combined mitigation effectiveness would therefore be 0.6 (visual) + 0.1 (acoustic) = 0.7 (total).

Table B-4 summarizes aerial, surface, acoustic, and combined mitigation effectiveness estimates. Combined mitigation effectiveness is estimated to range from 0.43-0.89 for baleen whales. Values are 0.93-0.96 for most dolphins and toothed whales; exceptions are sperm whale (0.81) and Cuvier's beaked whale (0.43).

B.2 MARINE TURTLES

B.2.1 Species Descriptions of Marine Turtles

The loggerhead sea turtle (*Caretta caretta)* is found from South America to New England. This species generally occurs in subtropical waters. Juveniles are pelagic, often drifting in current gyres for several years. It is believed that subadults move to nearshore and into estuarine areas. Adult loggerheads concentrate within middle shelf to shelf edge waters (Schroeder and Thompson, 1987). Adults are found along the continental shelf of the Atlantic and Gulf of Mexico. Loggerheads feed primarily on benthic molluscs and crustaceans. Pelagic stages feed on coelenterates and cephalopods. Mating occurs in late March to early June. Nesting occurs from May to September. Most nesting of the western Atlantic population occurs on beaches of southeast Florida with other nesting areas located in northeast Florida, Georgia, South Carolina, and North Carolina, as well as the Gulf coast of Florida. Incubation lasts about

Table B-4. Summary of estimated mitigation effectiveness for marine mammals.

Species	Mitigation Effectiveness			
	Aerial (ME_{aerial})	Surface ($ME_{surface}$)	Acoustic ($ME_{acoustic}$)	Combined[a] ($ME_{combined}$)
BALEEN WHALES				
Fin whale (E)	0.44	0.855	0.25	0.89
Humpback whale (E)	0.44	0.855	0.25	0.89
Minke whale	0.24	0.24	0.25	0.43
Sei whale (E)	0.44	0.855	0.25	0.89
Sei/Bryde's whale	0.44	0.855	0.25	0.89
Unidentified *Balaenoptera* spp.	0.44	0.855	0.25	0.89
Unidentified large whale	0.44	0.855	0.25	0.89
TOOTHED WHALES AND DOLPHINS				
Atlantic spotted dolphin	0.44	0.855	0.50	0.93
Bottlenose dolphin	0.44	0.855	0.50	0.93
Bottlenose/Atlantic spotted dolphin	0.44	0.855	0.50	0.93
Clymene/spinner/striped dolphin	0.44	0.855	0.75	0.96
Common dolphin	0.44	0.855	0.50	0.93
Cuvier's beaked whale	0.24	0.24	0.25	0.43
Pantropical spotted dolphin	0.44	0.855	0.50	0.93
Pilot whale	0.44	0.855	0.50	0.93
Risso's dolphin	0.44	0.855	0.50	0.93
Sperm whale (E)	0.24	0.24	0.75	0.81
Spinner dolphin	0.44	0.855	0.75	0.96
Striped dolphin	0.44	0.855	0.75	0.96
Unidentified dolphin	0.44	0.855	0.50	0.93
Unidentified small whale	0.44	0.855	0.50	0.93

(E) = endangered species.

[a] Combined mitigation effectiveness was calculated as:

$$ME_{combined} = ME_{visual} + [ME_{acoustic} \times (1 - ME_{visual})],$$

where ME_{visual} is equal to ME_{aerial} or $ME_{surface}$, whichever is greater.

54 days in Florida and 63 days in Georgia. Hatchlings swim out to 22 to 28 km (12 to 15 nmi) offshore and begin a pelagic existence within *Sargassum* algae rafts. This species is currently listed as threatened. Murphy and Hopkins (1984) estimated that there were 14,150 nesting females utilizing southeast U.S. beaches in 1983, based on aerial and ground survey data. The NMFS and U.S. Fish and Wildlife Service (USFWS) (1991b) estimated that there are approximately 58,000 nests deposited per year in the southeastern U.S. State agencies in Florida, Georgia, South Carolina, and North Carolina have estimated that approximately 50,000 to 70,000 nests are deposited annually in this region, according to the loggerhead turtle recovery plan prepared by the NMFS and USFWS (1991b).

The leatherback sea turtle (*Dermochelys coriacea*) is a circumglobal species, currently divided into two subspecies (Thompson and Huang, 1993). The subspecies of interest here is *Dermochelys coriacea coriacea* which inhabits waters of the western Atlantic Ocean from Newfoundland to northern Argentina. It is believed that compared to other sea turtles, leatherbacks range the farthest north. This species may be found in shallow waters but is essentially open ocean, or pelagic (Marquez, 1990). Leatherback sea turtles are frequently observed in cool waters of higher latitudes, such as New England and the Canadian Maritime Provinces. Leatherback sea turtles are pelagic feeders (e.g., on coelenterates, particularly jellyfish). This species nests on high energy beaches (i.e., beaches exposed to strong wave action) in Florida as early as late February or March. Incubation lasts 65 days. Very little is known of the pelagic distribution of hatchling and/or juvenile leatherback turtles. Due to the endangered status of the leatherback turtle, all nesting areas are considered critical habitat.

The Atlantic green sea turtle (*Chelonia mydas*) occurs in U.S. Atlantic waters around the U.S. Virgin Islands, Puerto Rico, and continental waters from Texas to Massachusetts. This species may be found in convergence zones in deep water and in shallow, protected waters containing benthic (bottom) feeding grounds. Atlantic green sea turtles commonly feed upon seagrasses and algae, using reefs and rocky outcrops near grass beds for resting areas. Nesting areas are located on high-energy beaches along the Atlantic coast of Florida. The NMFS and USFWS (1991a) identified several large and important nesting areas along the central and southeast coast of Florida, including Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties. Mating occurs in waters off nesting areas. Nesting occurs at night, with females producing clutches of eggs every two years. Hatchlings swim out to sea and enter a pelagic stage in convergence zones.

Hawksbill sea turtles (*Eretmochelys imbricata)* occur in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. In the western Atlantic, hawksbill turtles are generally found in clear tropical waters of the Caribbean, including the Florida Keys, the Bahamas, and the southwest Gulf of Mexico. Hawksbill turtles are not frequently reported in waters north of Cape Canaveral, Florida. Adults can be found in waters up to 100 m (328 ft) deep. This species feeds on encrusting organisms, particularly sponges. Juvenile hawksbill sea turtles are usually found near shallow coral reefs. Nesting areas for hawksbills in the Atlantic are found in the U.S. Virgin Islands, Puerto Rico, and south Florida. Hatchlings enter a pelagic phase, drifting with *Sargassum* rafts. Juveniles shift to a benthic foraging existence in shallow waters, progressively moving to deep waters as they grow and become capable of deeper dives for sponges. Due to this turtle's endangered status, all nesting areas are critical habitat. Within the continental U.S.,

nesting beaches are restricted to the southeast coast of Florida (i.e., Volusia through Dade Counties) and the Florida Keys (Monroe County), as noted by Meylan (1992) and the NMFS and USFWS (1993).

The Kemp's ridley sea turtle (*Lepidochelys kempii*) is found from the Gulf of Mexico to New England, and occasionally as far north as Nova Scotia. Its distribution along the U.S. southeastern coast is mediated by the Gulf Stream. Adult turtles are usually found in the Gulf of Mexico. Juveniles may move northward along the U.S. Atlantic coast with the warm waters of the Gulf Stream. Individuals are reported to return southward when waters turn cold. It is believed that this species typically remains shoreward of the 50-m (164-ft) contour line. Kemp's ridley sea turtles forage in shallow water, feeding on crabs, shrimp, gastropods, and fish. Nesting occurs almost entirely in Rancho Nuevo beach, Tamaulipas, Mexico (NMFS and USFWS, 1992). Nesting occurs during the day in April, May, and June, with mature individuals returning on an annual basis (Prichard and Marquez, 1973). Due to the species' endangered status, all nesting areas are considered as critical habitat. According to the NMFS and USFWS (1992), juvenile and subadult Kemp's ridley sea turtles travel northward along the Atlantic seaboard in spring to feed in the productive, coastal waters between Georgia and New England; these migrants then move southward with the onset of cooler temperatures in late fall and winter. Henwood and Ogren (1987) and Schmid (1995) provided information on length frequency, seasonal occurrence, and long distance migratory patterns of Kemp's ridley sea turtles along the U.S. Atlantic coast.

B.2.2 Adjustment of Marine Turtle Densities for Submerged and Undetected Individuals

Six aerial surveys were conducted at Mayport and Norfolk during 1995 to estimate densities of marine turtles, as described in Section B.1.3. Densities calculated from these aerial observations do not take into account submerged individuals or those that may have been on the surface but undetected. Therefore, adjusted densities were developed for the two species (loggerheads and leatherbacks) seen during the surveys. Adjusted densities were calculated using the same method described above for marine mammals. The following equation was used:

$$D_{adj} = D_{obs}/P$$

where D_{adj} is the adjusted density, D_{obs} is the observed density, and P is the proportion of the total population believed to be detected by the aerial surveys. P was calculated as follows:

$$P = S_t \times ADP$$

where S_t is the probability of an animal being on the surface at any given time, and ADP is the aerial detection probability (the probability that an individual on the surface would be detected from the air).

Probabilities of being on the surface (S_t) were estimated by reviewing literature on the dive times of marine turtles and by consulting with turtle experts, including scientists at the NMFS. Marine turtles at sea are believed to be submerged most of the time; probabilities of being on the surface were estimated at 0.1 for loggerheads and 0.12

for leatherbacks (Thompson, 1995). Aerial detection probabilities (ADP) were estimated based on animal length and herding tendencies using the same scoring system developed for marine mammals (see Section B.1.4). Both loggerheads and leatherbacks were assigned length scores of 1 (length of 1-1.5 m [3-5 ft]) and herding scores of 0 (herding not likely), resulting in a total score of 1 and an ADP of 0.3.

Table B-5 summarizes the results of these calculations for marine turtles. The table shows mean densities for the six-month survey period (April through September 1995). Because there would be no shock testing in April at Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April). Observed mean densities (May-September at Mayport, April-September at Norfolk) were about 0.5 individuals/100 km^2 at both areas. However, because only a small portion of either population is believed to be on the surface (S_t = 0.1 or 0.12) and because only 30% of animals on the surface are estimated to have been detected from the air (ADP = 0.3), adjusted densities are about 30 times higher than observed densities.

B.2.3 Mitigation Effectiveness Calculations for Marine Turtles

The Marine Mammal and Sea Turtle Protection/Mitigation Plan (see Section 5.0 of the DEIS) includes the use of aerial and shipboard observers and passive acoustic surveys to detect sea turtles within the safety range prior to detonation. For impact analysis, it was necessary to estimate mitigation effectiveness, i.e., the probability of detecting an animal if present.

The approach to estimating mitigation effectiveness for sea turtles was similar to the one described above for marine mammals (Section B.1.5). However, it is assumed that passive acoustic monitoring would not detect any turtles; therefore, $ME_{combined}$ was defined as the maximum of ME_{aerial} or $ME_{surface}$ (whichever is greater).

B.2.3.1 Aerial Monitoring

For aerial monitoring, mitigation effectiveness (ME) was calculated as:

$$ME_{aerial} = ADP \times S_{aerial}$$

where ADP is aerial detection probability as defined previously, and S_{aerial} is the probability of an animal being on the surface at least once during aerial monitoring. ADP calculations have been discussed above in Section B.2.2; both loggerheads and leatherbacks were assigned length scores of 1 (length of 1-1.5 m [3-5 ft]) and herding scores of 0 (herding not likely), resulting in a total score of 1 and an ADP of 0.3.

Because aerial monitoring would involve three complete passes over the site prior to detonation (see Section 5.0), the probability of an animal being on the surface during at least one pass (S_{aerial}) would be higher than the S_t values presented above in Section B.2.2 (i.e., 0.1 for loggerheads and 0.12 for leatherbacks). Using the S_t values from Table B-5 to represent the probability of an animal being on the surface at any given time, the probability of an animal being on the surface during at least one of three passes can be estimated using binomial theory (Winkler and Hays, 1975):

Table B-5. Adjustment of 1995 aerial survey data to account for submerged and undetected sea turtles.

Species	Probability of Being on Surface (S)	Aerial Detection Calculations			Proportion of Population Detected ($P = S \times ADP$)	Mayport Densities[a] All Six Surveys (Individuals/100 km^2)		Mayport Densities[a] Excluding April (Individuals/100 km^2)		Norfolk Densities[a] All Six Surveys (Individuals/100 km^2)	
		Length Score	Herding Score	Aerial Detection Probability (ADP)		Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)
Loggerhead sea turtle (T)	0.10	1	0	0.3	0.030	0.72	24.12	0.46	15.15	0.50	16.63
Leatherback sea turtle (E)	0.12	1	0	0.3	0.036	0.03	0.94	0.04	1.13	0.01	0.31
Unidentified sea turtle	0.11[b]	NA	NA	0.3[b]	0.033[b]	0.02	0.69	0.02	0.62	0.03	1.03
TOTAL MARINE TURTLES						**0.78**	**25.75**	**0.52**	**16.90**	**0.54**	**17.97**

(E) = endangered species. (T) = threatened species. NA = not applicable.

[a] Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data. Some values may differ slightly from those one could calculate using the tabulated numbers.

[b] Composite values were assigned for unidentified species.

$$P \text{ (on surface at least once in three trials)} = 1 - (1 - S_t)^3$$

This calculation yields S_{aerial} values of 0.27 for loggerheads and 0.32 for leatherbacks.

This method assumes that the three passes during aerial monitoring would be independent sampling events. Because sea turtles can dive deep and remain submerged for several hours, an individual animal could be submerged on the same dive during successive passes. However, the assumption would still be reasonable when applied to the population as long as dives of individual animals are independent (i.e., some could be surfaced and others submerged at a given time). Because most of the sea turtles seen during 1995 aerial surveys were solitary animals, this is a reasonable assumption.

Table B-6 shows the S_{aerial} and aerial detection probability (ADP) values for each turtle species. The product of ADP and S_{aerial} is the aerial mitigation effectiveness (ME_{aerial}) for each species.

B.2.3.2 Surface Monitoring

For surface monitoring, mitigation effectiveness (ME) was calculated as:

$$ME_{surface} = SDP \times S_{surface}$$

Surface detection probabilities (SDP) were calculated as described above under marine mammals (Section B.1.5). Both loggerheads and leatherbacks were assigned length scores of 1 (length of 1-1.5 m [3-5 ft]), herding scores of 0 (herding not likely), and visibility enhancement scores of 0 (very poor), resulting in a total score of 1 and a SDP of 0.3.

$S_{surface}$ is probability that an animal would be on the surface within 4 to 6 nmi of the detonation point at least once during the 2.5 hours preceding detonation. In order to be <u>not</u> detectable by surface observers, an animal would have to be submerged during the entire time it was present in the area. Sea turtles can dive deep and remained submerged for several hours. The probability of being on the surface at least once during 2.5 hours would be higher than the surface probability (S_t) listed in Table B-5. A conservative assumption is that $S_{surface}$ would be no less than S_{aerial} defined above, which is based on three independent aerial passes rather than continuous surface observations.

Table B-7 shows the SDP and $S_{surface}$ values for each turtle species. The product of these two values is the surface mitigation effectiveness ($ME_{surface}$) for each species.

B.2.3.3 Combined Mitigation Effectiveness

Mitigation effectiveness calculations for sea turtles are summarized in **Table B-8**. It is assumed that passive acoustic monitoring would not detect any turtles; therefore, $ME_{combined}$ was defined as the maximum of ME_{aerial} or $ME_{surface}$ (whichever is greater). $ME_{combined}$ is estimated at 0.08 for loggerheads, 0.10 for leatherbacks, and 0.09 for unidentified turtles. In other words, most sea turtles presumably would not be

Table B-6. Estimated mitigation effectiveness of aerial monitoring for sea turtles.

Species	Length Score	Herding Score	Aerial Detection Probability (ADP)[a]	Probability of Being on Surface (S_{aerial})	Aerial Mitigation Effectiveness (ME_{aerial})[b]
Loggerhead sea turtle (T)	1	0	0.3	0.27	0.08
Leatherback sea turtle (E)	1	0	0.3	0.32	0.10
Unidentified sea turtle	NA	NA	0.3[c]	0.30[c]	0.09[c]

(E) = endangered species. (T) = threatened species. NA = not applicable.
a ADP depends on sum of length and herding scores (see text).
b ME_{aerial} = ADP x S_{aerial}.
c Composite values were assigned for unidentified species.

Table B-7. Estimated mitigation effectiveness of surface monitoring for sea turtles.

Species	Length Score	Herding Score	Visibility Enhance-ments Score	Surface Detection Probability (SDP)[a]	Probability of Being on Surface ($S_{surface}$)	Surface Mitigation Effectiveness ($ME_{surface}$)[b]
Loggerhead sea turtle (T)	1	0	0	0.3	0.27	0.08
Leatherback sea turtle (E)	1	0	0	0.3	0.32	0.10
Unidentified sea turtle	NA	NA	NA	0.3[c]	0.30[c]	0.09[c]

(E) = endangered species. (T) = threatened species. NA = not applicable.
a SDP depends on sum of length, herding, and visibility enhancements scores (see text).
b $ME_{surface}$ = SDP x $S_{surface}$.
c Composite values were assigned for unidentified species.

Table B-8. Summary of estimated mitigation effectiveness for sea turtles.

Species	Mitigation Effectiveness			
	Aerial (ME_{aerial})	Surface ($ME_{surface}$)	Acoustic ($ME_{acoustic}$)	Combined[a] ($ME_{combined}$)
Loggerhead sea turtle (T)	0.08	0.08	0.00	0.08
Leatherback sea turtle (E)	0.10	0.10	0.00	0.10
Unidentified sea turtle	0.09	0.09	0.00	0.09

(E) = endangered species.

a Combined mitigation effectiveness was calculated as:

$ME_{combined} = ME_{visual} + [ME_{acoustic} \times (1 - ME_{visual})]$,

where ME_{visual} is equal to ME_{aerial} or $ME_{surface}$, whichever is greater.

detected because they are likely to be submerged or, if present on the surface, not visible to aerial or surface observers due to their small size, solitary habits, and lack of visibility enhancements.

B.3 SEABIRDS

The following range, habitat, general life history information, and expected presence for open ocean seabirds of concern which may occur offshore of Mayport, Florida and Norfolk, Virginia has been adapted from Rowlett (1980), Clapp et al. (1982a,b, 1983), Powers (1983), Lee (1984, 1985b, 1986), and Lee and Horner (1989).

Black-browed albatrosses (*Diomedea melanophrys*) are an accidental visitor to North Carolina in April, August, and December. Their presence in shelf waters of the northern Chesapeake Bight is hypothetical. They are classified as a vagrant (accidental) in the north Atlantic.

Northern fulmars (*Fulmarus glacialis*) are found in the Arctic Ocean south to Newfoundland. They winter at sea south of New Jersey and feed in the open ocean on squid, shrimp, and fish. Northern fulmars nest in rocky cliffs. They are common to abundant in waters off North Carolina in spring and fall. There are no records of this species south of the Carolinas.

Northern gannets (*Sula bassana*) are common to abundant visitors to waters off North Carolina in winter and spring, although present year round. They are also abundant in waters off Florida's Atlantic coast and present from October to April, with peak abundances seen from November to February.

Brown boobies (*Sula leucogaster*) are found in tropical waters in the Gulf of Mexico. They feed on flying fish and breed on coastal islands. Brown boobies are considered rare visitors to North Carolina waters with sightings noted for April and December. They are probably casual post-breeding vagrants in late summer and early fall over shelf waters of the northern Chesapeake Bight. Brown boobies are considered to be rare in waters off Florida's Atlantic coast, although occurrence is possible year round.

Masked boobies (*Sula dactylatra*) are associated with tropical waters around the Bahamas and West Indies. They are occasionally found in Florida, Louisiana, and Texas. Masked boobies feed in the open sea on fish, particularly flying fish, and breed in colonies on open ground. There is a single suspect record for North Carolina. Masked boobies are rare visitors to central and southern segments of Florida's Atlantic coast, with most records from August to September.

Red-billed tropicbirds (*Phaethon aethereus*) are uncommon visitors to waters off North Carolina in spring and summer. Similarly, they are uncommon in waters off Florida's Atlantic coast. Red-billed tropicbirds are more uncommon in the southeastern U.S. than their congeners, the white-tailed tropicbirds (*P. lepturus*).

White-tailed tropicbirds (*Phaethon lepturus*) are uncommon visitors to waters off North Carolina in summer. They are probably casual late summer and early fall vagrants over warm slope waters and eddies of the Gulf Stream (along the edge of the

continental shelf) of the northern Chesapeake Bight. They are frequently sighted in waters off Florida's Atlantic coast.

Magnificent frigatebirds (*Fregata magnificens*) are uncommon visitors to waters off North Carolina in spring and summer and casual vagrants during spring, summer, and fall over shelf waters of the northern Chesapeake Bight. They occur year-round in waters off Florida's Atlantic coast, though more common during summer.

Cory's shearwaters (*Puffinus diomedea*) occur on the east coast of North America during summer and fall. They feed in the open ocean and typically follow ships. Cory's shearwaters nest in rock crevices or on open ground. They are common to abundant off North Carolina in spring, summer, and fall and a fairly common, widely dispersed summer visitor in shelf waters of the northern Chesapeake Bight. Cory's shearwaters are the most abundant shearwater in waters off Florida's Atlantic coast from May to December. Peak numbers are seen from September to November.

Greater shearwaters (*Puffinus gravis*) breed in large colonies on small islands in the southern Atlantic but migrate to the north Atlantic during summer. They feed in the open ocean on small fish and squid. Greater shearwaters are common in waters off North Carolina in spring and summer, though most abundant in waters of the Gulf Stream and along the edge of the continental slope. They are uncommon during late spring, summer, and fall as a visitor to shelf waters of the northern Chesapeake Bight. They are locally abundant during June and early July and, occasionally fairly common from late October to early November. Greater shearwaters are relatively uncommon in waters off Florida's Atlantic coast and are seen in all months except March and April.

Audubon's shearwaters (*Puffinus lherminieri*) are found in tropical waters but may occur as far north as New York during summer. They nest in colonies on islands. They are common to abundant off North Carolina in spring, summer, and fall. Audubon's shearwaters are rare summer and early fall visitors to shelf waters of the northern Chesapeake Bight. They are the second most abundant shearwater in waters off Florida's Atlantic coast, with peak numbers from July to early November. It is suggested that they are present year round.

Manx shearwaters (*Puffinus puffinus*) are occasional visitors in the western Atlantic. They are mostly seen at sea from Newfoundland to Cape Hatteras. Manx shearwaters undergo very long migrations. They breed in colonies on islands in the eastern Atlantic. They are rare visitors to waters off North Carolina in winter and spring. They are rare transients in spring and fall over shelf waters of the northern Chesapeake Bight and have been recorded only rarely in waters off Florida's Atlantic coast, with most observations during fall and winter.

Sooty shearwaters (*Puffinus griseus*) are abundant to common visitors in waters off North Carolina in May and June, although present year round. They are uncommon spring and early summer transients over the entire shelf of the northern Chesapeake Bight. Sooty shearwaters are relatively rare in waters off Florida's Atlantic coast. There, it is suggested that their peak abundance is in May and June, although data are limited.

Wilson's storm-petrels (*Oceanites oceanicus*) occur on the western Atlantic during summer. They generally feed in the open ocean but sometimes enter bays and estuaries. They breed in rocky cliffs and on offshore islands in the Antarctic and subantarctic seas and are common to abundant off North Carolina in spring, summer, and fall. Wilson's storm-petrels are summer visitors to shelf waters of the northern Chesapeake Bight and are locally abundant beyond 50 km (27 nmi) offshore. They are the most abundant storm-petrel in waters off Florida's Atlantic coast; presence noted from April to November with peak numbers seen in May and June.

Leach's storm-petrels (*Oceanodroma leucorhoa*) are found in Labrador south to Maine. They breed in colonies on rocky islands and coasts in the eastern Atlantic and winter in the open ocean. They are common off North Carolina in spring and late summer, although also present in fall. Leach's storm-petrels are rare and widely dispersed from April to November in shelf waters of the northern Chesapeake Bight, although probably present in fall and winter. They are considered rare visitors to waters off Florida's Atlantic coast.

Band-rumped (Harcourt's) storm-petrels (*Oceanodroma castro*) are inhabitants of tropical and subtropical seas. They occur in the western North Atlantic from late May through mid-August, although peak abundance is in mid-July. They are highly pelagic and generally solitary. Band-rumped storm petrels are common visitors to deep waters (500 to 1,000+ fathoms) off North Carolina in summer. Their occurrence in waters off Florida's Atlantic coast is considered accidental.

White-faced storm-petrels (*Pelagodroma marina*) are rare visitors to waters off North Carolina in fall. They are probably casual late summer and fall vagrants to shelf waters of the northern Chesapeake Bight. Strays may rarely be encountered south of Cape Hatteras. No records for this species are known from waters off Florida's Atlantic coast.

Black-capped petrels (*Pterodroma hasitata*) are tropical to subtropical in distribution. Nesting occurs within burrows located on steep forested cliffs of Caribbean islands. They are common visitors to waters off North Carolina year round, most commonly in May, October, and December. The majority of sightings have been over deep water (914 to 1,829+ m [3,000 to 6,000+ ft]), though less common between 183 to 914 m (600 to 3,000 ft). Black-capped petrels are thought to be casual vagrants to shelf waters of the northern Chesapeake Bight. They apparently migrate to Gulf Stream waters. Only a few historic sightings of this species have been made in waters off Florida's Atlantic coast.

Bermuda petrels (Cahow) (*Pterodroma cahow*) are subtropical. Their distribution at sea is unknown. They are a very rare species which feed on squid, shrimp, and small fish in the open sea. They breed in burrows in Bermuda, though not likely to be found at the Mayport or Norfolk areas except accidentally. Bermuda petrels are considered rare visitors to waters off North Carolina, with sightings noted in April and December. No sightings records for this species have been made in waters off Florida's Atlantic coast.

Red-necked phalaropes (*Phalaropus lobatus*) are common to abundant visitors to waters off North Carolina in spring and fall. They are abundant as transients in waters

off Florida's Atlantic coast and most abundant in April and May and September and October.

Red phalaropes (*Phalaropus fulicaria*) are common to abundant visitors to waters off North Carolina in fall, winter, and spring. They are fairly common spring and fall transients to shelf waters of the northern Chesapeake Bight, though uncommon and irregular in winter. They are found usually beyond 70 km (38 nmi) from shore. Red phalaropes are common to abundant in waters off Florida's Atlantic coast as a winter migrant.

Pomarine jaegers (*Stercorarius pomarinus*) are common visitors to waters off North Carolina in spring and fall. They are primarily transients over shelf waters of the northern Chesapeake Bight. Pomarine jaeger are uncommon in spring, though fairly common in fall. Data suggests that they are present year round.

Parasitic jaegers (*Stercorarius parasiticus*) are common visitors to waters off North Carolina in fall, although uncommon in spring. Similarly, they are uncommon spring and fall transients to shelf waters of the northern Chesapeake Bight, with few sightings noted in summer.

Long-tailed jaegers (*Stercorarius longicaudus*) are uncommon visitors to waters off North Carolina year round. They are rare spring and fall transients to shelf waters of the northern Chesapeake Bight.

Great skuas (*Catharacta skua*) are rare visitors to waters off North Carolina in winter. They are rare but regular winter visitors and probable spring transients over shelf waters of the northern Chesapeake Bight. They occur primarily seaward of the 120-m (394-ft) contour to the continental slope.

South polar skuas (*Catharacta maccormicki*) are uncommon visitors to waters off North Carolina in summer.

Black-legged kittiwakes (*Rissa tridactyla*) are common visitors to waters off North Carolina in winter. They are common fall and early spring transients and winter visitors to shelf waters of the northern Chesapeake Bight, seaward of 10 km (5.4 nmi) offshore.

Sabine's gulls (*Larus sabini*) are rare visitors to waters off North Carolina in May, September, and October. They are casual spring and fall transients over shelf waters of the northern Chesapeake Bight.

Arctic terns (*Sterna paradisaea*) are rare in waters off North Carolina in spring. Similarly, they are rare spring and probably fall transients over shelf waters of the northern Chesapeake Bight, beyond the 55-m (180-ft) contour. Data suggest they occur off the Atlantic coast of Florida in spring over pelagic waters.

Bridled terns (*Sterna anaethetus*) are found in the nonbreeding season in offshore waters from the Carolinas to Florida. They breed in colonies in tropical waters of the Atlantic on rocky or sandy islands. They are abundant to common in waters off North Carolina in summer and fall. Similarly, they are casual late summer visitors (i.e., when

surface temperatures reach a maximum) to shelf waters of the northern Chesapeake Bight. Bridled terns occur regularly in some numbers in waters off Florida's Atlantic coast in summer and fall, with peak numbers realized in late April and May, and again in August and September.

Sooty terns (*Sterna fuscata*) are common visitors to waters off North Carolina in summer. They are casual vagrants in summer and early fall over shelf waters of the northern Chesapeake Bight, and are most frequently observed following tropical storms and hurricanes. Sooty terns occur frequently in waters off Florida's Atlantic coast, and often seen following hurricanes. Their highest abundances are noted from late summer through early fall.

Brown noddies (*Anous stolidus*) are rare visitors to waters off North Carolina in summer. They are rare in waters off Florida's Atlantic coast and often seen following hurricanes.

Dovekies (*Alle alle*) are uncommon visitors to waters off North Carolina in fall and winter. They are uncommon winter visitors (November to March) to shelf waters of the northern Chesapeake Bight.

Thick-billed murres (*Uria lomvia*) are uncommon visitors to waters off North Carolina in winter.

Razorbills (*Alca torda*) are uncommon visitors to waters off North Carolina in winter. They generally range offshore to the 55-m (180-ft) contour within shelf waters of the northern Chesapeake Bight.

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APPENDIX C

ENDANGERED SPECIES ACT CONSULTATION

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ENDANGERED SPECIES ACT CONSULTATION

This appendix contains copies of the informal consultation letters written prior to preparation of the Draft Environmental Impact Statement. There are eight letters in total. The first letter from the Department of the Navy is an example of letters sent to request informal consultation; similar letters were sent to various personnel of the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). The next three letters are subsequent response letters from the NMFS to the Navy and occur in chronological order. The last four response letters are from the USFWS to the Navy and also occur in chronological order.

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
P.O. BOX 190010
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11000
064WS
23 May 95

Dr. Andrew Kemmerer
Regional Director
National Marine Fisheries Service
9721 Executive Center Drive North
St. Petersburg, Florida 33702

Dear Dr. Kemmerer:

We are in the process of producing an Environmental Impact Statement (EIS) for "shock testing" the SEAWOLF Submarine at a site to be located off the east coast of the United States. To assist us in this process, we have hired the firm Continental Shelf Associates, Inc. (CSA). Pursuant to 40 CFR 1501.6, the National Marine Fisheries Service (NMFS) will be a cooperating agency in the preparation and development of the EIS. The EIS will also provide requisite information under 50 CFR A 228.4 for the application of a Letter of Authorization from the NMFS for small takes of marine mammals under Section 101(a)(5) of the Marine Mammal Protection Act of 1972, and for a biological assessment to fulfill requirements listed in the Endangered Species Act of 1973 for the incidental take of listed species (50 CFR 402.12). To assist in the completion of these objectives, the Navy would like to initiate informal consultation with the NMFS for information necessary for the preparation of the EIS.

The SEAWOLF is a new class of submarine. Each new class of ships constructed for the Navy must undergo sea trials to ensure seaworthiness, safety, and combat readiness. Typically, one of the first ships of each class is shock tested to assess the survivability of the hull, all ship systems, and the crew. A shock test consists of a series of underwater detonations that are used to propagate a shock wave through a ship's hull, thus simulating underwater detonations which are similar to those encountered in combat. To approximate actual conditions and provide the best information, ship shock testing is conducted in offshore waters by exploding underwater charges and measuring the effects on the ship. The test provides important information which is used to improve the initial design and enhance the effectiveness and overall survivability of the crew and ship. These improvements are applied to follow-on ships of the same class. Each shock test will involve the detonation of a 10,000-pound charge at an approximate depth of 100 feet below the water surface. An operations vessel will moor at the test site and assemble and deploy a 1-mile long test array. The array will consist of the explosive charge, marker buoys, instrumentation, connecting ropes, and the "gate" which is a small diameter rope that the submarine breaks as it passes through the array. For each test, the submarine will submerge just below the surface, about 65 feet, and navigate in the direction of the prevailing current toward the

marker buoys located on each side of the gate. As the submarine passes through the gate, detonation of the explosive will be initiated from the operations vessel on verbal command. After an initial inspection for damage, the submarine will surface and then travel back to the shore facility for detailed post-test inspections and preparations for the next test. For each subsequent test, the gate will be moved closer to the explosive so the submarine will experience a more severe shock level. The program is planned for one detonation per week over a five-week period.

Candidate shock test areas that would be considered are off the coast of Norfolk, Virginia and Jacksonville, Florida, due to the proximity of supporting naval bases (**Figure 1**). An important logistical consideration for shock tests includes closeness of a naval base with a drydock capable of handling a submarine the size of SEAWOLF in case the vessel is damaged during the shock testing. A maximum water depth of 500 feet is required to ensure that bottom conditions do not affect the shock tests, to facilitate test operations, and to ensure the safety of the crew. For the areas being considered, a water depth of 500 feet ranges from 70 to 100 miles offshore. The Norfolk, Virginia test area lies along the continental shelf edge from the southern boundary of the proposed Norfolk Canyon National Marine Sanctuary at latitude 36°56.00' N to latitude 35°41.00' N. The Mayport, Florida test area lies along the approximate position of the west wall of the Gulf Stream, from latitude 31°25.00' N to 36°07.00' N.

The operational area within the selected test site is planned to be a 1 nautical mile diameter zone centered on the explosive charge. An exclusion zone of 5 nautical miles will be established around the test site to exclude all non-test ship, submarine, and aircraft traffic. This zone will be maintained free of radio communications and other electromagnetic interferences. Any traffic within a 10 nautical mile radius will be warned to alter course or will be escorted from the area. A Notice to Airmen and Mariners will be published in advance of the first test.

The SEAWOLF submarine will be ready for shock testing between April and October 1997. Shock testing must be completed by October 1997 due to the decrease in favorable weather conditions which occurs after this month.

CSA is presently conducting a systematic aerial survey program to assess spatial and temporal surface densities of marine mammals and sea turtles in the two candidate test areas (**Figures 2 and 3**). These surveys will be conducted monthly between April and September 1995. Results of the surveys will be incorporated into the Draft EIS (DEIS) and will be used to propose the most appropriate area for the shock test. In addition, a thorough review of the existing literature and data of marine mammal, sea turtle, and marine bird populations in the candidate test areas will be presented in the Existing Environment Section of the DEIS. A plan for mitigating and monitoring potentially adverse effects from the shock test will also be described in the DEIS. Elements of this plan include the selection of a test site, or sites, which would minimize the likelihood of encountering marine mammals and sea turtles, and a program involving extensive aerial and shipboard surveillance for species of concern which could be conducted prior to and after detonation. Pre-detonation surveillance, or monitoring, would delay shock

testing if a marine mammal or sea turtle is within the predetermined safety zone of the shock test site. The DEIS will also discuss additional specific mitigation measures.

For this stage of the project and the development of the prerequisite DEIS, the Navy would like to request initial background information which includes the following items:

- A listing of listed, proposed, and candidate species of concern for the proposed action, including known temporal and spatial movements; and

- A listing of designated or proposed critical habitats for the above listed species.

This information would provide a basis for descriptions of the existing environment with respect to federally protected and listed species. The Navy, assisted by CSA, would like to further consult with the NMFS regarding additional information on the existing environment, the development of the environmental consequences (or impacts) section for species or critical habitats of concern, and mitigation/monitoring associated with this project. Your assistance in expediting this request is greatly appreciated.

Sincerely,

L. M. PITTS
Head, Environmental Planning
By direction of
the Commanding Officer

Encl:
(1) Figure 1 - Candidate site aerial survey areas
(2) Figure 2 - Location of aerial survey area showing survey blocks and transects off Norfolk, Virginia
(3) Figure 3 - Location of aerial survey area showing survey blocks and transects off Mayport, Florida

copy to:
National Marine Fisheries Service, Gloucester, Massachusetts (Dr. Jon Rittgers)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Dr. N.
St. Petersburg, FL 33702

JUN 26 1995 F/SE013:KRW:jbm

Mr. L. M. Pitts
Head, Environmental Planning
Department of the Navy
Southern Division, Naval
Facilities Engineering Command
P.O. Box 190010
North Charleston, NC 29419-9010

Dear Mr. Pitts:

This letter is in response to your May 23, 1995 request to initiate informal consultation under the Endangered Species Act on proposed ship shock testing of the Navy SEAWOLF submarines. You requested information on 1) a listing of listed, proposed, and candidate species of concern for the proposed action, including known temporal and spatial movements; and 2) a listing of designated or proposed critical habitats for the above-listed species.

With respect to marine mammals, the answers to most of your questions are contained in the enclosed draft copy of the *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments*. This document lists the marine mammal species to be found in the area, describes their status, and provides a description of their geographic range, including information on temporal and seasonal movements (if available). This document also cites numerous references which would be useful to you in preparing your DEIS. When the final Atlantic Stock Assessment reports are published, we will forward them to you, as some of the numbers in the draft will be changed in the final version. Of the many marine mammal species present in the proposed ship shock test area off Jacksonville, only six are listed (all as endangered). These include the northern right whale, *Eubalaena glacialis*, the humpback whale, *Megaptera novaeangliae*, the sperm whale, *Physeter macrocephalus*, the blue whale, *Balaenoptera musculus*, the fin whale, *B. physalus*, and the sei whale, *B. borealis*.

One additional marine mammal, the harbor porpoise, *Phocoena phocoena*, has been proposed for listing as a threatened species. This species occurs in the proposed site off Norfolk, Virginia. Harbor porpoise strandings have been recorded from as far south as Florida in winter (Polacheck, Wenzel and Early, 1991); but the southern end of the species' normal range is believed to extend only to North Carolina (Marine Mammals Investigation, 1992).

Critical habitat has been established for only one of the above marine mammal species: the northern right whale. A copy of the regulations defining this area is enclosed, as the proposed ship shock test site near Mayport, Florida is within this critical habitat area. Right whales have been sighted in this area between the months of October and May (Mead, 1986), although they are most prevalent between late November and March, with fewer numbers sometimes lingering through April (Kraus *et al.*, 1993). A copy of the Northern Right Whale Recovery Plan is enclosed for your information.

With respect to listed sea turtles, there are five species which may occur in the proposed area off Mayport. These include loggerheads, *Caretta caretta* (threatened), green turtles, *Chelonia mydas* (the breeding population off Florida is listed as endangered; otherwise, this species is considered threatened), leatherbacks, *Dermochelys coriacea* (endangered), hawksbills, *Eretmochelys imbricata* (endangered), and Kemp's ridleys, *Lepidochelys kempii* (also endangered). Enclosed you will find copies of sea turtle recovery plans and a number of scientific papers which provide information on sea turtle distribution and movement patterns, as you requested. No critical habitat has been designated for sea turtles within or near the proposed shock trial sites. Also enclosed are documents which provide background information on fish resources in the area.

The above documents should all be useful in preparing the affected environment section of your DEIS. Your letter indicates that you would also appreciate additional information for use in preparing the environmental consequences and mitigative measures sections of the DEIS. References, which should assist you with the former, are included in the enclosed list. A list of experts who would be good contacts regarding information on the effects

of sound on marine organisms is also enclosed. The draft EISs prepared for the proposed ATOC experiments (both for California and Hawaii) contain a brief literature review of the effects of sound on various marine animals, as well as an extensive discussion of this topic. An address where copies of the ATOC EISs may be obtained is enclosed. These resources should be reviewed, as well as other NEPA documentation previously prepared for similar Navy activities.

In brief, the DEIS should address the hearing capabilities of marine mammals and sea turtles, the characteristics of the sounds (e.g., intensity, frequency, duration, properties of spreading, etc.) that will be produced by the explosions and other noises associated with the ship shock tests, the levels of received sounds from these sources at various distances from the source, "zones of influence" upon any potentially affected marine mammal, sea turtle, or prey species (e.g., fish and squid), including at what distances the blasts or associated shock waves, etc., could result in injury or mortality of these animals and at what distances could these sounds be considered a disturbance to these animals (e.g., interfering with normal communications, prey detection, etc.).

The document should also address any by-products of the explosion such as possible pollutants and their potential effects, as well as a discussion of the long-term fate of the pollutant by-products. Information on whether they may become assimilated biologically, such as methylated byproducts, should also be included. Additionally, a plan to clean-up debris resulting from the explosion is necessary. Other international environmental agreements may need to be considered for the NEPA review, such as MARPOL, the Ocean Dumping Act, the Toxic Substance Control Act, etc. A permit may be required if the detonation by-products are listed as toxic.

In addition to clean-up of debris following explosions, mitigative measures should include, but not necessarily be limited to, use of any available and practicable means of detecting marine mammals and/or sea turtles in the area, and assurances that prior to detonation, it will be determined to the best of the Navy's ability (i.e., through use of aerial surveys,

side-scanning sonar, monitoring of sonobuoys, etc.) that no such animals are present within any zone of influence of the blast site. Other protective measures should include demonstration that there will be adequate communication between any protected species observers and those responsible for conducting the tests, in order to ensure that no blast is initiated when such animals are present, and that any succeeding blasts will be terminated if any such animal is noted subsequent to the initial blast (either alive or dead). Tests should occur during daylight hours only, unless it can be demonstrated that the Navy has adequate means of detecting marine mammals/sea turtles after dark.

Aerial surveys should also be conducted immediately following the ship shock tests, in order to assess any possible takes/effects of marine mammals/sea turtles and other wildlife, as well as at some period (perhaps two to four weeks) afterward to observe whether sightings of marine mammals and sea turtles are within a normal range for the time period. Local stranding networks should be notified in advance to be alert to a possible increase in strandings; this should be monitored via follow-up contacts subsequent to the tests. If stranding levels are notably high after the initial explosions, future tests should be cancelled or placed on hold until the circumstances can be reviewed by both NMFS and the Navy.

Although you state that the proposed ship shock tests would occur between April and October of 1997, your letter indicates that pre-test aerial surveys of the proposed sites will be conducted during the months of April through September, to determine tempero-spatial patterns of protected species in the two proposed test sites. If ship shock tests may occur in October, we strongly urge you to extend these surveys at least through that month. As seasonal patterns can vary in timing from year to year, extending the surveys at least another month beyond the latest potential test date is advisable. Additionally, it will be useful to have data on marine mammal/sea turtle distribution and abundance patterns for a two- to four-week time period following the test dates, to be used for comparison with post-detonation surveys as described above. However, in order to avoid interaction with right whales, it is advisable to restrict

ship shock activities to the months of June through August, if this is feasible.

Please be reminded that incidental take of marine mammals can only be authorized under an incidental take permit issued under MMPA Section 101(a)(5). The application procedures are enclosed.

Finally, we recommend that you also consult with the U.S. Fish and Wildlife Service with respect to the possible effects of these activities on seabirds.

If you have any further questions concerning this matter, please contact Dr. Katherine Wang of our Protected Species Management Branch at (813) 570-5312.

Sincerely,

Charles A. Oravetz

for Andrew J. Kemmerer
Regional Director

enclosures

cc: F/PR2: M. Payne, K. Hollingshead
NER: D. Beach

File: 1514-22-g.2.

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National Research Council. 1994. Low-frequency Sound and Marine Mammals: Current Knowledge and Research Needs. National Academy Press, Washington.

Young G.A. Concise Methods for Predicting the Effects of Underwater Explosions on Marine Life. Naval Surface Warfare Center, Dahlgren Division. NSWC MP 91-220.

Other Useful Resources on the Effects of Noise on Marine Organisms

ATOC DEISs available through: Ms. Pat Aguilar, Campus Planning Office, 0006, 9500 Gilman Dr., Univ. of California, San Diego, CA 92093 (619) 534-3860.

Dr. Darlene Keton, Dept. of Otolaryngology, Harvard Medical School, MEEI (617) 573-0483 (hearing in marine mammals and sea turtles)

Dr. Art Myrberg, University of Miami, Rosenstiel School of Marine and Atmospheric Science (305) 361-4177 (effects of noise on fish)

Dr. Art Popper, University of Rhode Island, Naragansett, RI
(effects of noise on fish)

Scott Eckert, Scripps Inst. of Oceanography (involved with assessing effects of ATOC project on sea turtles)

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
One Blackburn Drive
Gloucester, MA 01930

JUL 19 1995

Mr. L.M. Pitts
Head, Environmental Planning
Department of the Navy
Southern Division
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, SC 29419-9010

Re: The preparation of an Environmental Impact Statement (EIS) for "shock testing" the SEAWOLF Submarine at a site to be located off the east coast of the United States.

Dear Mr. Pitts:

The Navy proposes a series of ship shock tests to be conducted in offshore waters by exploding underwater charges and measuring the effects on the ship. Each proposed shock test will involve the detonation of a 10,000-pound charge at an approximate depth of 100 feet below the water surface.

Norfolk site

Enclosed is a list of endangered and threatened marine species within the purview of the National Marine Fisheries Service (NMFS) Northeast Region that are likely to occur in the project vicinity. In addition to the listed species, the Atlantic bottlenose dolphin (Tursiops truncatus, coastal population only) is listed as "depleted" under the Marine Mammal Protection Act, and the harbor porpoise (Phocoena phocoena) is proposed for listing as "threatened" under the Endangered Species Act. For more information concerning endangered species issues, please contact the Protected Species Program at (508) 281-9254.

ENDANGERED

Right whale (Eubalaena glacialis) - Cape Cod area from December to June. Lower Bay of Fundy from July to November. Migrate along entire shelf to Florida from November to June. A few sightings have been made in the Norfolk Canyon area primarily in the spring and fall when migratory aggregations are observed.

Humpback whale (Megaptera novaeangliae) - Southern edge of Gulf of Maine and off southern New England from April to December. They are also found off Virginia and Maryland primarily in the fall and winter.

Fin whale (Balaenoptera physalus) - All continental shelf waters in all seasons. They are most prominent near the Norfolk Canyon area in the spring.

Sperm whale (Physeter macrocephalus) - Found along the continental shelf edge waters in all seasons. Sperm whales are concentrated along the 1000 meter contour and are relatively abundant in the Norfolk Canyon area during spring and summer months.

Kemp's ridley sea turtle (Lepidochelys kempii) - Inhabit inshore bay and estuarine habitats from Hatteras to Cape Cod Bay from July to November. In Virginia waters they can be present from April 15/May 15 to November.

Leatherback sea turtle (Dermochelys coriacea) - Inhabit large open bays from June to November. The southern migration (MA to VA) occurs in nearshore waters from August to November. This pelagic species has been sighted in the Norfolk Canyon area in summer months.

THREATENED

Loggerhead sea turtle (Caretta caretta) - Found along the continental shelf area throughout the Mid-Atlantic and in large bays from July to November as far north as Cape Cod Bay. In Virginia waters they can be present from April 15/May 15 to November. This species has also been sighted in the Canyon area.

In addition, other marine mammals (not regarded as endangered or threatened) have been observed in Norfolk Canyon and adjacent waters, such as the Minke whale (Balaenoptera acutorostrata), Long Finned Pilot whale (Globicephala melaena), Short Finned Pilot whale (Globicephala macrorhynchus), Grampus whale (Grampus griseus), Striped dolphin (Stenella coeruleoalba), and Spotted dolphin (Stenella attenuata; S. rontalis; S. plagiodon).

Minke whales occur in the shelf waters of the Canyon and adjacent waters primarily in the spring.

The long and short finned pilot whales occur along the 100 meter contour seasonally and are also found offshore as well. In the summer, they concentrate along the 2000 meter contour.

Sightings of Grampus whales also occur between the 100 meter and 2000 meter contour, primarily in the fall and summer.

Striped dolphin occur along the shelf edge, at the 100 meter contour and offshore over the continental slope and rise. Although they are common year round, they have been sighted in the greatest density in the spring.

The distribution of Atlantic bottlenose dolphins is generally centered about the 1000 meter contour. Nearshore, they periodically move into the mouth of Chesapeake Bay and other estuaries.

Two species of Spotted dolphins also occur along the Canyon and adjacent shelf areas in the spring.

In addition to marine mammals and turtles, the waters in the project vicinity contain a deep-sea demersal fish fauna dominated by the macrourids (rattails), morids (codlings), gadids (cods, hakes), zoarcids (eelpouts) and synaphobrandchids (cutthroat eels). Decapods and echinoderms are also well represented among megafaunal organisms.

Proposed shock test site block #1 encroaches into the Proposed Norfolk Canyon National Marine Sanctuary. The Norfolk Canyon is located approximately 60 nautical miles off of the mouth of the Chesapeake Bay and the coast of Virginia, and is the southernmost submarine canyon in a series of prominent deep water features on the eastern continental margin of the United States. The area, 262 square nautical miles, recommended for the proposed sanctuary provides habitat for a distinctive assortment of living marine resources. Two species of soft coral (Paragorgia arborea; Primnoa reseda) rarely encountered elsewhere, have been documented in the Canyon. Stands of these gorgonian "trees" are as much as 2 meters high. To protect the unique fauna of the proposed Marine Sanctuary from shock waves, we recommend a buffer area be implemented of at least 2.5 nautical miles from it's southern most boundary.

The DEIS should address the environmental concerns raised by our Southeast Regional Office. We concur with their comments that the effects of this project on marine mammals, sea turtles, and their prey species be addressed. These concerns include: effects of auditory sounds produced by underwater explosions on protected resources; effects of by-products of the explosion on the animals in the short- and long-term, as well as their long-term fate; and monitoring these animals before and after explosions to determine impact to protected resources. Mitigative protective measures should also be included in the DEIS.

If you would like to discuss this project further, please contact John C. Stremple at (410) 226-5771.

Sincerely,

Dr. Andrew A. Rosenberg
Regional Director

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Region
One Blackburn Drive
Gloucester, MA 01930

NATIONAL MARINE FISHERIES SERVICE

Endangered Species List for Northeast Region

ENDANGERED -

Right whale (Eubalaena glacialis) - Cape Cod area from December to June. Lower Bay of Fundy from July to November Migrate along entire shelf to Florida from November to June.

Humpback whale (Megaptera novaeangliae) - Southern edge of Gulf of Maine (MA, NH, ME) and off southern New England (MA, RI, NY - Long Island) from April to December. They are also found off Virginia and Maryland in the winter.

Fin whale (Balaenoptera physalus) - All continental shelf waters in all seasons.

Sperm whale (Physeter macrocephalus) - Found along the continental shelf edge waters in all seasons.

Blue whale (Balaenoptera musculus) - Found in open seas, usually in colder sub-artic waters. Occasionally seen in NE>.

Sei whale (Balaenoptera borealis) - Found along the eastern and southern edge of Georges Bank.

Kemp's ridley sea turtle (Lepidochelys kempii) - Inhabit inshore bay and estuarine habitats from Hatteras to Cape Cod Bay from July to November.

Leatherback sea turtle (Dermochelys coriacea) - Inhabit large open bays from June to November. The southern migration (MA to VA) occurs in nearshore waters from August to November.

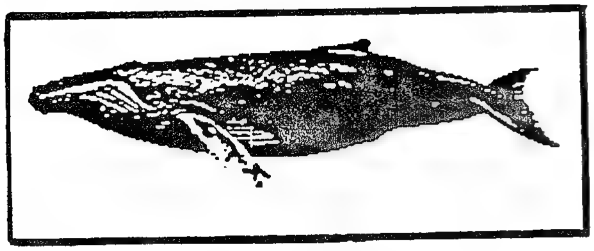
Green sea turtle (Chelonia mydas) - Occasionally seen in nearshore waters from MA to VA from July to November.

Shortnose sturgeon (Acipenser brevirostrum) - Found in the lower reaches of all major river systems.

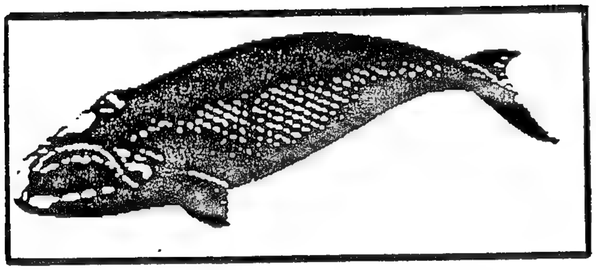
THREATENED -

Loggerhead sea turtle (Caretta caretta) - Found along the continental shelf and in large bays from July to November as far north as Cape Cod Bay.

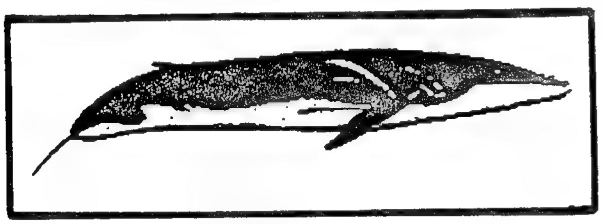
CETACEANS



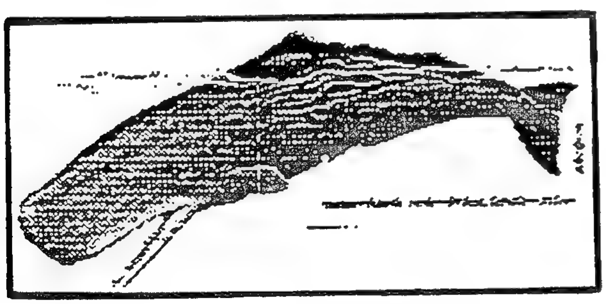
Humpback whale - Occur from the Gulf of Maine, over Georges Bank, to southern New England in spring, summer, and fall. Found in small groups on coastal banks. Mid-sized whale (25-45 feet) with a small irregular dorsal fin, long (more than 1/3 of body length) white flippers, and white on the underside of the tail flukes. Feeds on krill and small schooling fishes.



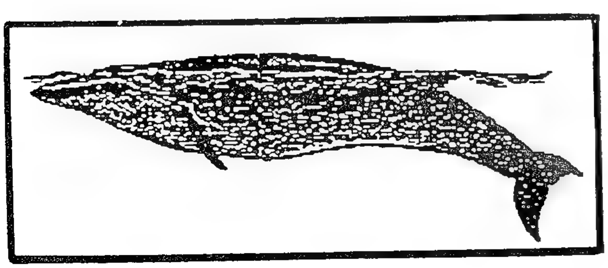
Right whale - Occur in the Gulf of Maine, Great South Channel, and southern edge of Georges Bank in summer and fall. Large (30-50 feet) stocky black whale with no dorsal fin. White markings may be seen on top of the head. Blow characteristic, V-shaped. Feeds primarily on zooplankton.



Fin whale - Occur throughout the Northeast shelf waters in all seasons. Large (50-70 feet) dark grey whale with a white lower jaw on the right side only. Light grey chevron markings may be seen behind the blowhole. Feeds on small fishes, pelagic crustaceans, and squids.



Sperm whale - Found along edge of the continental shelf in Atlantic during all seasons. Rarely at depths less than 100 fathoms. Large (to 69'), snout blunt, squarish. Dark brownish gray, distinct dorsal hump 2/3 of way back from snout tip. Flukes broad, triangular. Feeds primarily on squids.

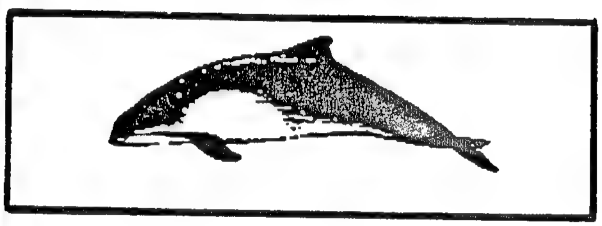


Sei whale - Found along the eastern and southern edge of Georges Bank during all seasons. Some animals move inshore in Bay of Fundy in summer. Large (to 62'), dark steel-gray body, snout slightly arched, paired blowholes, dorsal fin tall, strongly falcate. Feeds on surface plankton, krill, small schooling fishes, and squids.

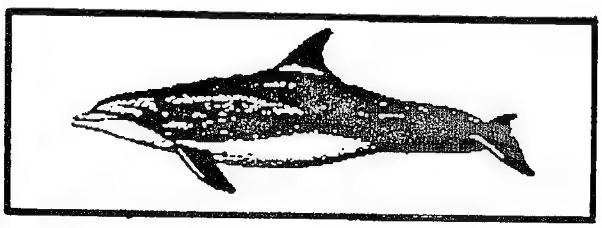
CETACEANS CONTD.

Blue whale - Mostly found in open seas although sometimes they occur in shallow, inshore waters. Largest cetacean species, to 98', they are light bluish-gray above. Belly is sometimes yellowish. Dorsal fin is extremely small and far back on tail stock. Feeds primarily on krill.

PROPOSED FOR LISTING



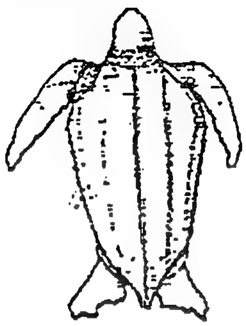
Harbor Porpoise - Occur in the Gulf of Maine year-round, and east and southeast of Cape Cod in spring and summer. Small (less than 6 feet) all black porpoise with white on the belly. The head is rounded and blunt, with no beak. Dorsal fin triangular. Feeds on fish and squid.



Bottlenose dolphin (coastal population only) - Mid-Atlantic coastal migratory stock ranges from Florida to New Jersey in spring, summer, and fall. Mid-sized (9-12'); grey dolphin with a white belly and short beak. Dorsal fin falcate. Feeds on variety of fish, squids, shrimps and crabs.

SEA TURTLES

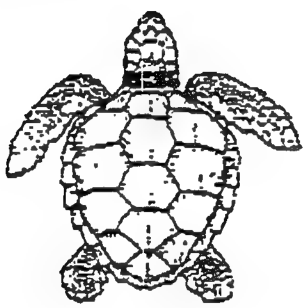
LBST



Leatherback -

Found in open water throughout the Northeast in the summer. Leathery shell with 5-7 ridges along the back. Largest sea turtle (4-6 feet) Dark green to black, may have white spots on flippers and underside.

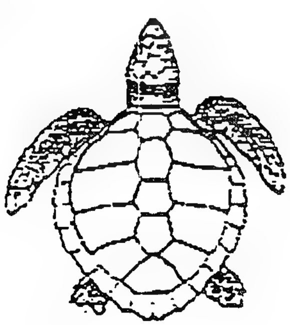
LGST



Loggerhead

Bony shell, reddish-brown in color. Mid-sized sea turtle (2-4 feet). Commonly seen from Cape Cod to Hatteras from spring through fall, especially in southern portion of range. Head large in relation to body.

RST

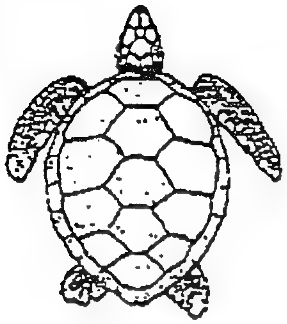


Kemp's ridley

Most often found in Bays and coastal waters from Cape Cod to Hatteras from summer through fall. Offshore occurrence undetermined. Bony shell, olive green to grey in color. Smallest sea turtle in Northeast (9-24 inches). Width equal to or greater than length.

SEA TURTLES (Cont.)

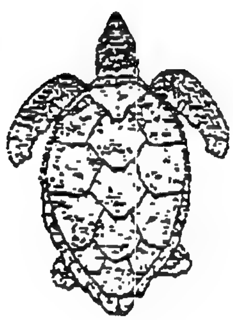
GST



Green turtle

Uncommon in the Northeast. Occur in Bays and coastal waters from Cape Cod to Hatteras in summer. Bony shell, variably colored; usually dark brown with lighter stripes and spots. Small to mid-sized sea turtle (1-3 feet). Head small in comparison to body size.

HST



Hawksbill

Rarely seen in Northeast. Elongate bony shell with overlapping scales. Color variable, usually dark brown with yellow streaks and spots (tortoise-shell). Small to mid-sized sea turtle (1-3 feet). Head relatively small, neck long.

FISH

Shortnose sturgeon

SNS

Occur in the major river systems along the Atlantic seaboard. Found offshore only within a few miles of land. Shortnose have a wide mouth, short snout, and are brownish to black in color, with bony plates along the sides of the body Rarely reach 4 feet.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

AUG 24 1995

Mr. L.M. Pitts
Head, Environmental Planning Division
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, SC 29419-9010

Dear Mr. Pitts:

Thank you for your letter requesting the National Marine Fisheries Service (NMFS) to be a cooperating agency (as that term is defined by the Council on Environmental Quality (40 CFR 1501.6)), in the preparation of a Draft Environmental Impact Statement (DEIS) for shock testing of the SSN-21, a SEAWOLF-class submarine.

We support the U.S. Navy's determination to do a DEIS on this activity and have been participating in both the scoping process under the National Environmental Policy Act and more recent planning sessions on scheduling and content of the DEIS. As a result, we agree with the schedule that the Navy has established to complete the shock trial by mid-1997. In cooperating with the U.S. Navy on this activity, NMFS will have a dual role, both through (and limited to) review and comment on the document's preparation and through the regulatory process involved with the issuance of an incidental small take authorization under section 101(a)(5)(A) of the Marine Mammal Protection Act. NMFS will also be in consultation with the U.S. Navy for this activity under section 7 of the Endangered Species Act. Therefore, although NMFS agrees to be a fully cooperating agency in the preparation of the DEIS, because of its regulatory role, we believe that it would be inappropriate for NMFS to be a signatory agency on the document. As a result, we reserve the ability to review that document when it is released to the general public, and to provide the U.S. Navy with appropriate comments. Provided our comments are addressed in the Final EIS, NMFS is prepared to adopt the U.S. Navy FEIS when making the final decision on the issuance of the small take authorization.

If you have questions or need additional information, please contact Mr. Kenneth Hollingshead, at 301/713-2055.

Sincerely,

William W. Fox, Jr. Ph.D.
Director
Office of Protected Resources

cc: F/PR, F/PR2-Hollingshead, F/PR2-Reading File, F/SER-Oravetz, F/SER-Coogan, F/NER-Beach, GCF
KHollingshead:F/PR2:713-2055:08/21/95:c:\ken50\\navy\seawcoop.ltr

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

In Reply Refer To:
FWS/R4/RANC/AES

April 16, 1996

Mr. L. M. Pitts, Head, Environmental Planning
Department of the Navy
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, South Carolina 29419-9010

Dear Mr. Pitts:

Thank you for the opportunity to reevaluate the Department of the Navy/Continental Shelf Associates, Inc. notice of intent to prepare an Environmental Impact Statement (EIS) for the SEAWOLF Submarine "shock testing" site located near Norfolk, Virginia along the continental shelf edge. Our original response was sent to your office on June 23, 1995. This letter responds to your recent letter dated April 15, 1996. Our comments are provided in accordance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) (Act).

Based on the information provided in previous correspondence as well as your recent letter, the Service has determined that this project is not likely to adversely affect any Federally-listed endangered or threatened species under the purview of this agency. We are pleased to note that your agency plans to consult with the National Marine Fisheries Service concerning sea turtles, marine mammals and other species protected by Federal mandate.

Please note that in the future, in accordance with Section 7 (a)(2)(3) of the Act, if threatened and endangered species are present on the project site, the Federal agency authorizing, funding or carrying out the action is responsible for the final effect determination the project may have on Federally-listed species and forwarding that determination to the Service (or NMFS) for concurrence.

We believe that the requirements of Section 7 of the Act have been satisfied. We remind you that obligations under Section 7 consultation must be reconsidered if: (1) new information reveals impacts of this identified action that may affect listed species or critical habitat in a manner not previously considered; (2) this action is subsequently modified in a manner that was not considered in this review; (3) a new species is listed or critical habitat determined that may be affected by the identified action.

Thank you for your cooperation with our agency.

Sincerely,

Tom Augspurger
Acting Supervisor

FWS/R4:KGRAHAM:KLG:4/15/96:919/856-4520 ext. 28: SEAWOLF.CON

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
P.O. Box 480
6983 Mid-County Drive, Suite D
White Marsh, Virginia 23183

July 10, 1995

L. M. Pitts
Environmental Planning
Department of the Navy
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, S.C. 29419-9010

Re: "Shock Testing" the SEAWOLF Submarine

Greetings:

We have reviewed your request for information on endangered and threatened species and their habitats for the above referenced project. Based on the project description and location, it appears that no impacts to Federally listed species will occur. Should project plans change, or if additional information on the distribution of listed or proposed species becomes available, this determination may be reconsidered.

Sincerely,

Karen L. Mayne

Karen L. Mayne
Supervisor
Virginia Field Office

United States Department of the Interior

FISH AND WILDLIFE SERVICE
6620 Southpoint Drive, South
Suite 310
Jacksonville, Florida 32216-0912

AUG 0 9 1995

Mr. L.P. Pints
Head, Environmental Planning
Southern Division
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, S.A. 29419-9010

FWS Log No: 4-1-95-419D

Dear Mr. Pints:

This responds to your letter regarding the preparation of a draft Environmental Impact Statement for "shock testing" the SEAWOLF submarine approximately 40 miles east of Mayport Naval Station, Duval County, Florida.

There are no federally listed threatened or endangered species located at the proposed test site that are under the jurisdiction of the U.S. Fish and Wildlife Service. We suggest that you contact the National Marine Fisheries Service, 9450 Koger Boulevard, St. Petersburg, Florida 33702, for that agency's review, since they have jurisdiction over most marine mammals and endangered and threatened species in ocean waters.

We appreciate the opportunity to provide our comments.

Sincerely yours,

Michael M. Bentzien

Michael M. Bentzien
Assistant Field Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE
4270 Norwich Street
Brunswick, Georgia 31520

September 18, 1995

Mr. Will Sloger
Southern Division, Naval Facilities Engineering Command
U.S. Navy
2155 Eagle Drive
North Charleston, South Carolina 29418

RE: Environmental Impact Statement for Shock Testing the Seawolf Submarine
FWS Log 4-4-95-272

Dear Mr. Sloger:

Thank you for your September 13, 1995, FAX requesting information on Federally listed species that could be impacted by shock testing the Seawolf submarine near Jacksonville, Florida. Shock testing will involve detonation of a series of 10,000-pound charges at approximately 100 feet below the water surface to determine if the craft is seaworthy and combat ready. Tests will be conducted 70 to 100 miles offshore in water up to 500 feet deep to ensure that bottom conditions do not affect results of the shock tests or impact crew safety.

It is not likely that the shock testing 70 to 100 miles offshore will adversely affect Federally listed species or critical habitat under the Service's purview. Requirements of Section 7 of the Endangered Species Act have been satisfied. However, obligations under the Act must be reconsidered if (1) the project is modified in a manner not considered in this assessment; (2) a new species is listed or critical habitat is determined that may be affected by the project; or (3) new information indicates that the project may affect listed species or critical habitat in a manner not considered.

We appreciate the opportunity to comment during the planning stages of this project. If you have any questions, please call Robin Goodloe of my staff at (912) 265-9336.

Sincerely,

for Kathy Chapman

Deborah Harris
Acting Field Supervisor

APPENDIX D

POTENTIAL IMPACTS OF ACTIVITIES ON MARINE MAMMALS

James Craig
Christian Hearn

Naval Surface Warfare Center
Carderock Division
Bethesda, MD

APPENDIX D

This appendix summarizes information on the effects of underwater explosions on marine mammals. A review of marine mammal anatomy and mechanisms for injury from underwater explosions is included. Results from experiments conducted mainly with terrestrial mammals are used to develop criteria and ranges for lethal and non-lethal injury. This information is used in the Environmental Consequences section of the DEIS.

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APPENDIX D

POTENTIAL IMPACT OF ACTIVITIES ON MARINE MAMMALS

Potential impacts to marine mammals include both lethal and non-lethal injuries as well as brief physical discomfort and acoustic annoyance. Most obviously, immediate injury or death could occur as a direct result of proximity to the point of detonation. Short term lethal injury would be a result of massive combined trauma to internal organs. Non-lethal injury includes slight injury to internal organs as well as to the auditory system; however, delayed lethality can be a result of complications from individual or cumulative sub-lethal injuries. Discomfort to and annoyance of marine mammals could occur as a result of non-injurious physiological response to both the explosion-generated shockwave as well as to the acoustic signature of the detonation. It is very unlikely that injury would occur from exposure to the chemical by-products released into the surface waters (Young, 1984; and NSWC, 1992).

A. The Effects of Underwater Explosions on Marine Mammals[1]

"Considerable information about the anatomy of marine mammals is available, particularly with regard to the adaptations necessary for survival in the underwater environment. The possible effects of underwater shock waves on these animals can be inferred from the similarities and differences in anatomy between marine and land mammals....

[1] Section is largely excerpted from Hill (1978).

"All true marine mammals dive for food and are therefore adapted to changes in hydrostatic pressure.... The adaptations necessary to permit marine mammals to withstand the pressure changes involved in deep diving are found primarily in the air-filled spaces of the body - notably the lungs, respiratory passages, outer and middle ear and accessory sinuses. Since the air-filled spaces of the body are the primary sites of damage to land mammals by underwater shock waves, adaptations which allow marine mammals to tolerate pressure changes may also make them resistant to damage from shock waves," Hill (1978).

The actual vulnerability of marine mammals to underwater explosions is largely unknown -- only two reports[2] have been found which describe experiments involving cetaceans.

A.1. Thorax

The thorax of marine mammals is much more flexible than that of land mammals. Very few ribs are connected to the sternum with costal cartilage - especially in cetaceans - and the costal cartilage itself is flexible. Some odontocetes (toothed whales) have "floating ribs", unconnected either to the sternum or to other ribs. Such a loosely-connected thoracic cage may not reduce the effects of shock waves on the lungs, since a rigid shield may be necessary to afford considerable protection against damage.

---

[2] Todd, et al., 1993; and Myrick, et al., 1990.

A.2. Respiratory System

Respiratory passages and lungs of marine mammals, particularly cetaceans, are highly modified for diving.... Compared to terrestrial mammals, there is a striking increase in the amount of supportive structures, namely cartilage, collagen, smooth muscle and elastic tissue in the peripheral portions of the lung. Extensive supportive structures are also found in the upper airways. Cartilaginous support extends from the trachea into the smaller airways up to the junction with alveolar ducts. Dense layers of elastic tissue, just beneath the mucous membrane, encircle and connect the cartilage. All these supportive tissues probably make cetacean lungs and airways less vulnerable to damage by shock waves, since the boundaries between tissue and air are not as fragile as in land animals.

The lung structure of pinnipeds, especially seals, is more similar to that of land mammals, but there are other modifications of the respiratory system which are shared by both pinnipeds and cetaceans.... The lung size relative to body size of marine mammals does not differ much from that of land mammals. However, the ratio of tidal air volume to the total lung volume, and the ratio of air passage volume to the total air volume are higher for marine mammals. These are modifications for deep diving. Increased tidal air ratio means that more air in the lungs is renewed with each breath - facilitating rapid gas exchange. Larger relative air passage volume may permit total lung collapse during deep dives. Lungs are usually placed dorsally, and the diaphragm typically extends obliquely across the

thoracic cavity; thus, the lungs can completely flatten against the dorsal thoracic wall. The flexible thorax of these animals permits such a collapse, with the compressed air from the lungs being forced into the more rigid air passages....

Seals generally exhale before diving, or during the initial part of the dive, whereas some cetaceans have been observed to dive after inspiration. Thus, the diving depth at which total lung collapse occurs is probably less for pinnipeds than for cetaceans. Nevertheless, when the lungs are collapsed, they will certainly be less vulnerable to damage from shock waves. Upper air passages in land mammals (and probably marine mammals as well) are not primary damage sites.

A.3. Ears and Other Air-Spaces in the Head Region

The middle and outer ears, and the various sinuses associated with the ears of diving mammals also have protection against pressure changes. True seals (*Phocidae* - this group includes all the common seals of the Arctic) and cetaceans do not have any external ears. Instead, the external ear opening is usually a small pore or slit on the side of the head region. In pinnipeds, the external auditory canal is long and narrow and is supported by cartilage. The canal is also lined with a thick, highly vascularized "cavernous" tissue; it may expand during a dive by filling with blood and thus occupy the air-filled space in the canal. The seal's external ear-opening is usually closed while diving. Very dense bone surrounds the middle ear cavity, which is also lined with thick cavernous tissue, called the *corpus*

cavernosum. Seal biologists believe that this tissue fills with blood as the seal descends in order to equalize the air pressure within the middle ear cavity with the pressure in other ear passages connected to the inner ear via the eustachian tube.

In toothed whales, the external ear opening is very small, or closed entirely. The auditory canal and the middle ear are lined with cavernous tissue; the middle and inner ears are also surrounded by a system of air sinuses filled with a foam formed from an oil-mucous emulsion. These sinuses are bounded closely by the bones of the skull and by thick cavernous tissue. As in the pinniped ear, the cavernous tissue probably fills with blood as the animal dives, thus expanding into the cavity to equalize the internal air pressure with the external hydrostatic pressure.

It appears that the air spaces associated with the ears of pinnipeds and cetaceans are well protected against shock-wave damage, because these spaces are typically surrounded by bone or cartilage and are lined with cavernous tissue which is itself bounded by a tough, fibrous membrane. During deep dives, these air spaces might be reduced in size by filling of the cavernous tissue with blood. The eardrum of pinniped and baleen whales - it is not functional in toothed whales - may be damaged by shock waves. An injured animal may be partially incapacitated in this way, but it is not known to what extent pinnipeds and baleen whales rely on hearing for their survival. A ruptured eardrum could also cause a fatal secondary infection of the middle ear.

The highly modified nostrils (nares) of cetaceans contain additional air-containing sacs and passages. The lining of these passages is tough and elastic in sperm whales, and it seems possible that this is the case in all whales. If so, the nostrils are not likely to be principal sites of damage by shock waves.

A.4. Viscera

Other principal damage sites in *terrestrial* mammals are regions of hollow viscera containing gas.... Such gas bubbles are *probably* uncommon, since the presence of significant quantities of gas in the intestinal tracts of animals which spend a great deal of time passing through pressure differences of 20 atmospheres or more could cause considerable discomfort, pain, and even injury.

A.5. Skin and Body Walls

In the review of the effects of shock waves on terrestrial mammals, it is noted that larger animals are less vulnerable to damage than small animals. This is likely a function of the thicker body walls of the larger mammals. Most marine mammals are large animals, possessing thick body walls. The skin of cetaceans consists of a tough epidermis, usually less than 1 cm thick, under which is the thinner dermis, composed mainly of thick bundles of connective tissue. Below the dermis lies the hypodermis, or blubber, a layer of fatty tissue - up to 60 cm thick in larger whales. The skin of pinnipeds is similar, except that all layers are proportionately thinner. The blubber layer of the ringed seal ranges from 10 mm to 63 mm in thickness, depending on the size of the animal and the season. Arctic pinnipeds (except

walrus) also have a layer of fur which, along with the skin, is waterproofed by a thin film of oil.

(Measurements of) the acoustic properties of the blubber coat in porpoises (indicated that) although sound easily entered the blubber coat, "the blubber/muscle interface proved an excellent sound reflector." Shock waves are reflected and absorbed in a roughly similar manner to low amplitude sound waves. Thus, although only a small fraction of shock-wave energy would be reflected at the skin and water interface, a considerable fraction would be reflected at the blubber and muscle interface. This would correspondingly reduce the peak pressures of the shock wave entering the body of the animal. The unwettable skin and fur of pinnipeds would not be a good acoustic couple between the water and the body of the animal, and could reduce the intensity of a shock wave more than would the wet skin of cetaceans.

B. Injury from Underwater Explosions

"Events taking place during the reflection and absorption of shock waves at boundaries between two different media may cause death or damage when these boundaries are within living organisms. When a shock wave passes from tissue of one density to tissue of a different density (for example, from muscle to bone), the particle velocities imparted to these tissues will be different. If the peak pressure of the shock wave is high and the density difference between the tissues is large,

resulting in a large difference in particle velocity, the two tissues may be literally torn apart.

"Shock wave reflections at an interface between tissue and an air-filled cavity within a living organism can cause great damage to tissues at the interface. This situation is physically analogous to the reflection of an underwater shock wave from a water surface. If the peak pressure of the shock wave is high enough, a form of cavitation will occur within the tissue near the boundary. Tissue at this boundary will also explode into the air-space because of the high particle velocity normal to the boundary imparted by the reflecting shock wave. Pathological consequences of these two effects could be destruction of tissues, loss of integrity of the boundary, and possible haemorrhage if capillaries or blood vessels are present," (Hill, 1978).

During the early 1970's, numerous tests were conducted on terrestrial mammals to determine injury mechanism and injury tolerance from underwater explosions. General details on these tests are provided by Yelverton, et al. (1973). Specific explosion shockwave parameters and detailed pathological reports are provided by Richmond, et al. (1973). "[These and other] experiments have shown that the principal damage sites in mammals are the gas-containing organs - the most seriously affected major organs being the lungs and the hollow viscera.

"Lung injuries consist of the rupture of alveolar walls and lacerations of larger areas, with subsequent massive haemorrhage. Air emboli can also result when the boundaries between the alveolar spaces and adjacent capillary-beds rupture.

"Damage to the viscera is mainly restricted to those portions of the lower intestine containing pockets of gas.... The most common injuries to the viscera are rupture and bruising of intestinal walls, and bleeding from the blood vessels of the walls. Gut contents can escape into the peritoneal space if the intestinal wall is perforated.

"...(A)ir emboli produced by sublethal lung damage can lodge in the heart and brain, causing death by cardiac arrest or stroke.... (P)athological changes to the central nervous system [have been reported], but it is not clear whether these are caused by direct damage to the nervous system or are side-effects of injuries to the lungs or circulatory system. Extreme blast injury can involve the fracture of extremities and violent trauma to the thoracic cage and abdominal contents," (Hill, 1978).

"(L)arger animals are *less* subject to injury than small animals. This may be due to higher absorption of energy in the thicker body walls of larger animals. A rigid mass, either of bone or of an artificial nature, can afford some protection against shock waves. 'Rib markings' - areas of bruising and haemorrhage - have been

noted on the lungs of animals injured by underwater shock waves. These markings, indicating areas of greater damage, actually correspond to the spaces between the ribs, showing that the ribs protect the lungs beneath them.... (L)arge, uninflated lungs are less prone to be damaged by underwater shock waves than small, fully-inflated lungs," (Hill, 1978).

Figure 1 shows regression analyses of terrestrial animal test data from Yelverton (1981), as reported by BBN (1993). The curves shown in Figure 1 represent the best fit for "No Injury", "1% Mortality", and "50% Mortality" test data. These regression curves can be described by:

$$\ln I = 1.969 + 0.386 \ln M \quad \text{(No Injury)}$$

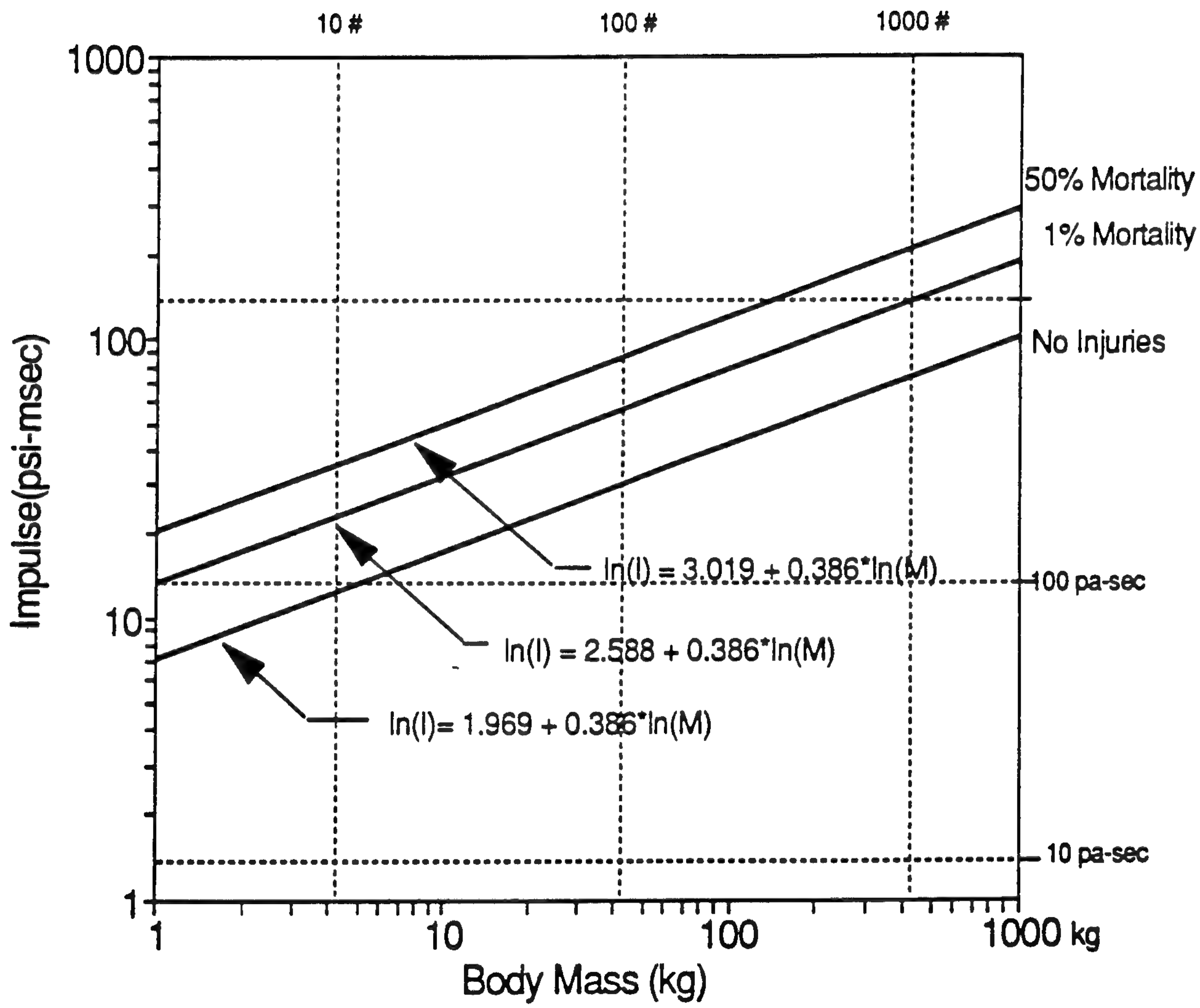
$$\ln I = 2.588 + 0.386 \ln M \quad \text{(1\% Mortality)}$$

$$\ln I = 3.019 + 0.386 \ln M \quad \text{(50\% Mortality)}$$

where I is impulse in psi-msec and M is body mass in kg.

B.1. Onset of Slight Lung Injury

Using data from the Yelverton, et al. (1973) report, Goertner (1982) developed a conservative computer model for the two primary injury mechanisms to mammals exposed to underwater explosion shockwaves. These mechanisms are: (1) lung hemorrhage, and (2) contusions of the G.I. tract. For lung hemorrhage, Goertner's model considers lung volume as a function of animal weight and depth and considers shockwave duration and impulse tolerance as a function of animal weight and depth.



Source: Yelverton (1981)

Figure 1. Regression Curves for Blast Damage to Mammals as a Function of Mammal Mass.

Injury to the G.I. tract was indexed to the ratio of peak shockwave pressure to the hydrostatic pressure at the mammal location. Injury to the G.I. tract is considered to be independent of mammal size and weight. G.I. tract injury is not specifically discussed in this section, since significant G.I. tract injury would generally be expected to occur at ranges less than the maximum ranges for the onset of slight lung injury.

Table 1 presents a comparison between actual small charge injury data (Richmond, et al., 1973) and predicted values based on the Goertner model. The reference values used in this application of the Goertner model are the lowest impulse and body mass for which slight lung injury was reported by Richmond, et al. (1973)--22.8 psi-msec (155.4 Pa-sec) and 93 lb (42 kg). After correcting for the atmospheric and hydrostatic pressures for the data, the minimum impulse for predicting onset of slight lung hemorrhage is:

$$I = 19.0\ (M/42)^{1/3}\ \text{psi-msec},$$

or

$$I = 129.5\ (M/42)^{1/3}\ \text{Pa-sec},$$

where M is the body mass (in kg) of the subject animal. The test data indicate the ranges, peak shockwave pressures and impulses for which slight lung hemorrhage

Table 1. Slight Lung Hemorrhage Model Verification.

EXPLOSIVE (Pentolite)		MAMMAL		TEST DATA'			MODEL PREDICTIONS'		
WEIGHT lb/(kg)	DEPTH ft/(m)	BODY MASS lb/(kg)	DEPTH ft/(m)	RANGE ft/(m)	PEAK PRESSURE psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)	RANGE ft/(m)	PEAK PRESSURE[3] psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)
1.052 (0.48)	10.0 (3.0)	108 (49)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	33 (10.1)	403 (2746)	20.2 (138)
1.052 (0.48)	10.0 (3.0)	101 (46)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	44 (13.4)	290 (1976)	19.9 (136)
1.052 (0.48)	10.0 (3.0)	75 (34)	1.0 (0.30)	26 (7.9)	588 (1007)	50.6 (345)	47 (14.3)	272 (1854)	18.0 (123)
1.052 (0.48)	10.0 (3.0)	35 (16)	1.0 (0.30)	26 (7.9)	588 (1007)	50.6 (345)	54 (16.5)	233 (1588)	14.0 (95)
1.052 (0.48)	10.0 (3.0)	44 (20)	1.0 (0.30)	26 (7.9)	478 (3257)	41.5 (283)	52 (15.9)	244 (1663)	15.1 (103)
1.052 (0.48)	10.0 (3.0)	13 (6)	1.0 (0.30)	26 (7.9)	478 (3257)	41.5 (283)	65 (19.8)	191 (1302)	10.1 (69)
1.052 (0.48)	10.0 (3.0)	82 (37)	2.0 (0.61)	33 (10.1)	436 (2971)	44.4 (303)	60 (18.3)	207 (1411)	18.9 (129)
1.052 (0.48)	10.0 (3.0)	90 (41)	2.0 (0.61)	33 (10.1)	436 (2971)	44.4 (303)	59 (17.9)	212 (1445)	19.5 (133)
1.052 (0.48)	10.0 (3.0)	93 (42)	10.0 (3.05)	48 (14.6)	269 (1833)	45.5 (310)	85 (25.9)	142 (968)	22.2 (151)
1.052 (0.48)	10.0 (3.0)	90 (41)	10.0 (3.05)	48 (14.6)	269 (1833)	45.5 (310)	86 (26.2)	141 (961)	22.0 (150)

Table 1. Slight Lung Hemorrhage Model Verification. (Continued)

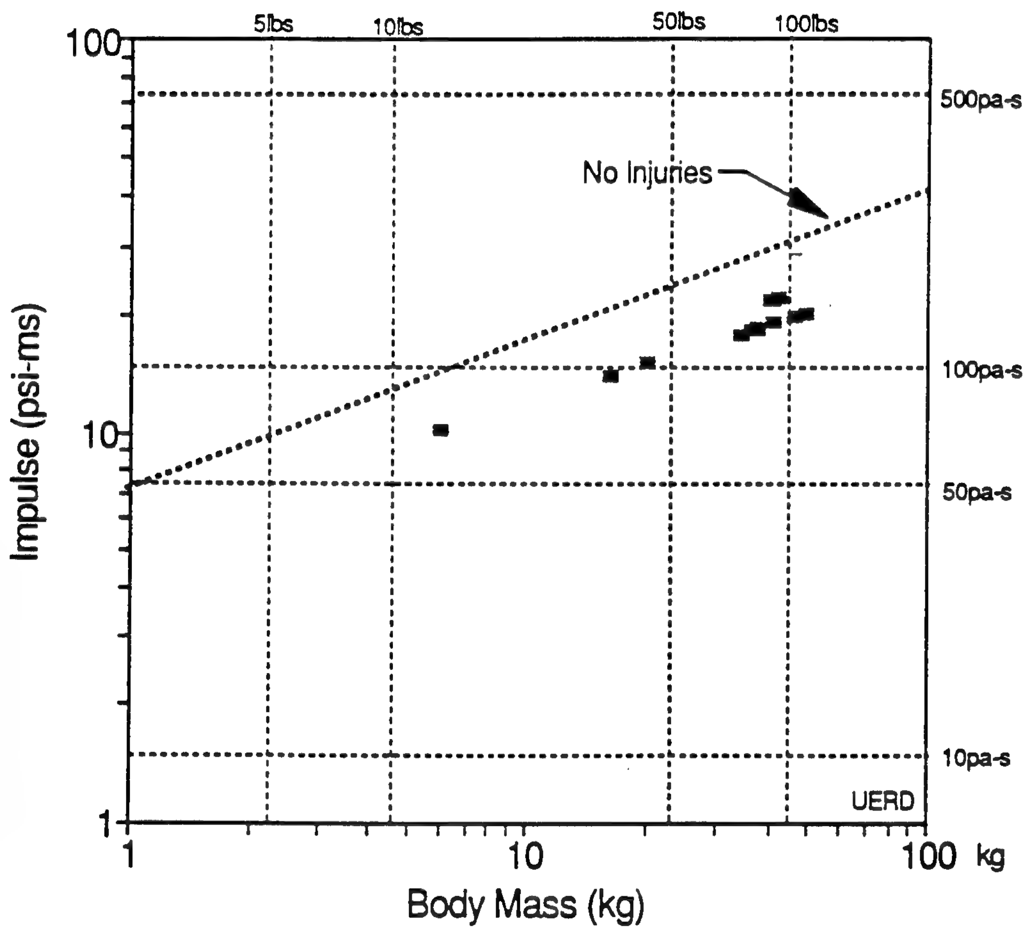
EXPLOSIVE (Pentolite)		MAMMAL		TEST DATA[4]			MODEL PREDICTIONS[2]		
WEIGHT lb/(kg)	DEPTH ft/(m)	BODY MASS lb/(kg)	DEPTH ft/(m)	RANGE ft/(m)	PEAK PRESSURE psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)	RANGE ft/(m)	PEAK PRESSURE[3] psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)
1.052 (0.48)	10.0 (3.0)	88 (40)	10.0 (3.05)	48 (14.6)	269 (1833)	45.5 (310)	86 (26.2)	139 (947)	21.8 (149)
1.052 (0.48)	10.0 (3.0)	93[1] (42)	10.0 (3.05)	84 (25.6)	153 (1043)	22.8[1] (155)	85 (25.9)	142 (968)	22.2 (151)
2.618 (1.19)	10.0 (3.0)	79 (36)	1.0 (0.30)	36 (11.0)	538 (3666)	40.3 (275)	58 (17.7)	304 (2072)	18.4 (125)
2.618 (1.19)	10.0 (3.0)	75 (34)	1.0 (0.30)	36 (11.0)	538 (3666)	40.3 (275)	58 (17.7)	301 (2051)	18.0 (123)
8.373 (3.80)	10.0 (3.0)	79 (36)	1.0 (0.30)	52 (15.8)	556 (3789)	33.2 (226)	73 (22.3)	357 (2433)	18.4 (125)
8.373 (3.80)	10.0 (3.0)	82 (37)	1.0 (0.30)	52 (15.8)	556 (3789)	33.2 (226)	73 (22.3)	359 (2447)	18.5 (126)
8.373 (3.80)	10.0 (3.0)	79 (36)	1.0 (0.30)	52 (15.8)	556 (3789)	33.2 (226)	73 (22.3)	357 (2433)	18.4 (125)

1 Occurrence of Slight Lung Hemorrhage (Richmond, et al., 1973)
2 Onset of Slight Lung Hemorrhage (after Goertner, 1982)
3 Weak Shock Theory (Gaspin, 1983)
4 Reference value for calculations

Source: CD-NSWC/UERD

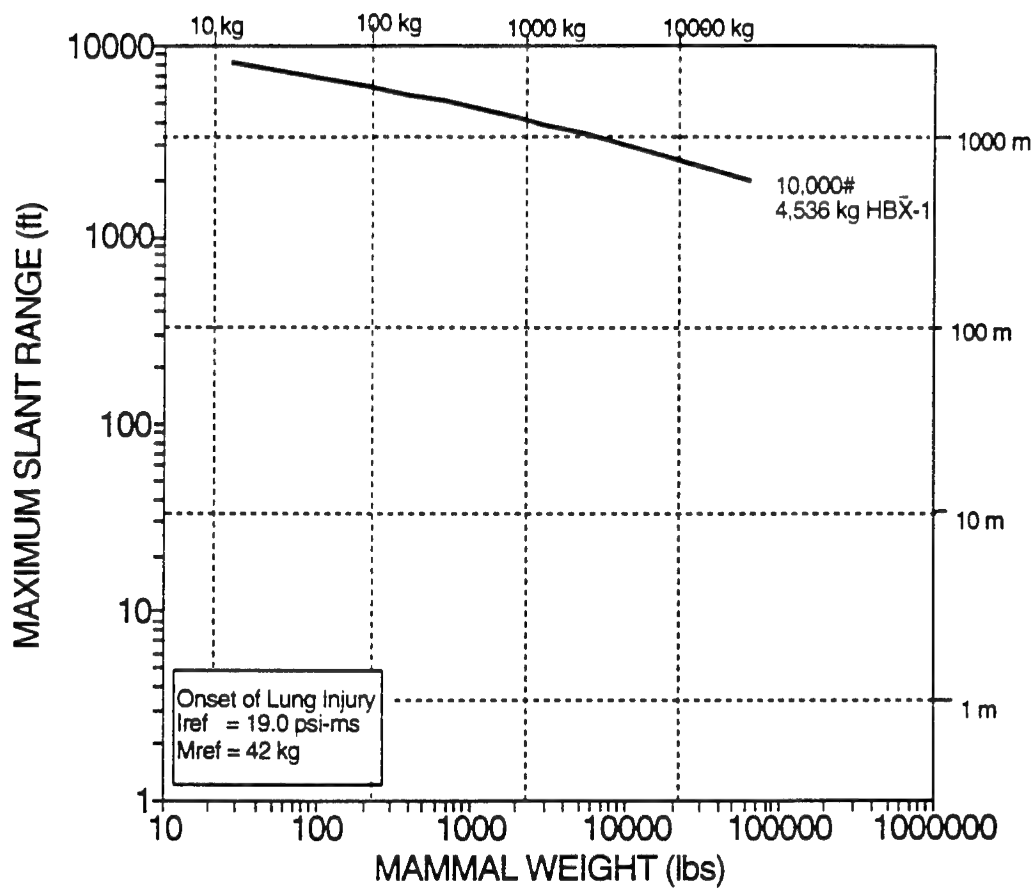
actually occurred to the test subject. The model predictions are ranges, peak pressures, and impulses which should describe conditions sufficient for the onset of slight lung hemorrhage. Regression curve values (Yelverton, 1981) indicate that for the range of body weights (masses) of 13 to 93-lb (6 to 42-kg), the "No Injury" impulses would be expected to range from 14.3 to 30.3 psi-msec (98 to 207 Pa-sec). Predictions for onset of slight lung injury based on actual test conditions using the Goertner model indexed to 19 psi-msec (130 Pa-sec) for a 93-lb (42-kg) mammal range from 10.1 to 22.2 psi-msec (69 to 151 Pa-sec). Figure 2 presents a comparison between the Yelverton (1981) "No Injury" regression curve for impulse vs. body mass and a plot of the predicted impulses for onset of slight lung hemorrhage for the test conditions in Table 1. In order for the onset of slight lung injury model to be conservative, the predicted impulse values must be no greater than either the test values or regression curve predictions and the predicted ranges must be no less than the test values. As can be seen in Table 1 and Figure 2, these conditions are met by the onset of slight lung injury model.

Figure 3 shows maximum calculated slant ranges for the onset of slight lung hemorrhage as a function of mammal weight for a 10,000-lb (4536-kg) charge. Slight lung hemorrhage is an injury from which a mammal would be expected to recover on its own and would not be debilitating. Charge and mammal depths have been varied so that the values shown in Figure 3 are conservative for any depths.



Source: Yelverton (1981), CD-NSWC/UERD

Figure 2. Comparison of Impulses for No-Injury and for Onset of Slight Lung Hemorrhage.



Source: CD-NSWC/UERD after Goertner (1982)

Figure 3. Calculated Ranges for Onset of Slight Lung Hemorrhage as a Function of Mammal Weight for a 10,000-lb (4536-kg) Charge.

Safety ranges for the shock test should be chosen conservatively to preclude injury (including eardrum rupture) to mammals of this size. The nominal calculated range for onset of slight lung hemorrhage for a 220-lb (100-kg) mammal from a 10,000-lb (4536-kg) charge (the charge to be used in the shock test) yields a maximum slant range of 6069 ft (1850 m) for the onset of slight lung hemorrhage.

B.2. Lethal Injury

B.2.1. Lethality from Injury to Internal Organs

"The major cause of immediate death due to underwater shock waves is suffocation caused by extensive haemorrhaging into the lungs. Air emboli can cause death soon after sublethal lung injury. In addition, fatal circulatory failure can occur, probably as a result of the obstruction of pulmonary circulation due to lung damage combined with general system shock. Death often occurs at some considerable time after the original injury. This usually comes about as a result of complications, such as broncho-pneumonia in damaged lungs, or peritonitis resulting from perforations of the intestinal wall," (Hill, 1978).

Richmond, et al. (1973) reported that the lowest impulse level to inflict extensive lung injury was 44.4 psi-msec (302.6 Pa-sec) for a 75-lb (34-kg) mammal. After correcting for atmospheric and hydrostatic pressures, and based on the cube root

scaling of body mass as used in the Goertner lung injury model, the minimum impulse for predicting onset of extensive lung hemorrhage is:

$$I_{1\%} = 42.0\ (M/34)^{1/3}\ \text{psi-msec}$$

or

$$I_{1\%} = 286.2\ (M/34)^{1/3}\ \text{Pa-sec},$$

where M is the body mass (in kg) of the subject animal and $I_{1\%}$ is the minimum impulse for 1% mortality. For a 93-lb (42-kg) animal, the predicted impulse for onset of extensive lung hemorrhage would be 45.1 psi-msec (307.4 Pa-sec). (From Section B.1, the minimum impulse level for predicting slight lung hemorrhage for the same 93-lb [42-kg] animal is 19.0 psi-msec [129.5 Pa-sec]). Although the Goertner model was not originally developed for mortality calculations, it lends itself to this use because of the ability to specify reference impulse and body mass values.

Table 2 provides a comparison between actual injury data (Richmond, et al., 1973), the Yelverton (1981) 1% Mortality regression curve, and predicted values based on the Goertner model as utilized in this document. The test data indicate ranges, peak shockwave pressures and impulses for which extensive lung hemorrhage actually occurred to the test subjects. The model predictions are ranges, peak pressures, and impulses which should describe conditions sufficient for the onset of extensive lung hemorrhage when using the modified Goertner model.

Table 2. Onset of Extensive Lung Hemorrhage (1% Mortality) Model Verification.

EXPLOSIVE (Pentolite)		MAMMAL		TEST DATA[1]			MODEL PREDICTIONS[2]		
WEIGHT lb/(kg)	DEPTH ft/(m)	BODY MASS lb/(kg)	DEPTH ft/(m)	RANGE ft/(m)	PEAK PRESSURE psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)	RANGE ft/(m)	PEAK PRESSURE[3] psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)
1.052 (0.48)	10.0 (3.0)	95 (43)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	21 (6.4)	684 (4661)	45.8 (312)
1.052 (0.48)	10.0 (3.0)	106 (48)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	20 (6.1)	702 (4784)	47.5 (324)
1.052 (0.48)	10.0 (3.0)	110 (50)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	20 (6.1)	708 (4825)	48.2 (328)
1.052 (0.48)	10.0 (3.0)	108 (49)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	20 (6.1)	705 (4805)	47.9 (326)
1.052 (0.48)	10.0 (3.0)	95 (43)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	26 (7.9)	522 (3557)	46.2 (315)
1.052 (0.48)	10.0 (3.0)	99 (45)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	26 (7.9)	528 (3598)	46.9 (320)
1.052 (0.48)	10.0 (3.0)	75[4] (34)	2.0 (0.61)	33 (10.1)	436 (2971)	44.4[4] (303)	34 (10.4)	394 (2685)	43.5 (296)

1 Occurrence of Extensive Lung Hemorrhage (Richmond, et al., 1973)
2 Onset of Extensive Lung Hemorrhage (after Goertner, 1982)
3 Weak Shock Theory (Gaspin, 1983)
4 Reference value for calculations

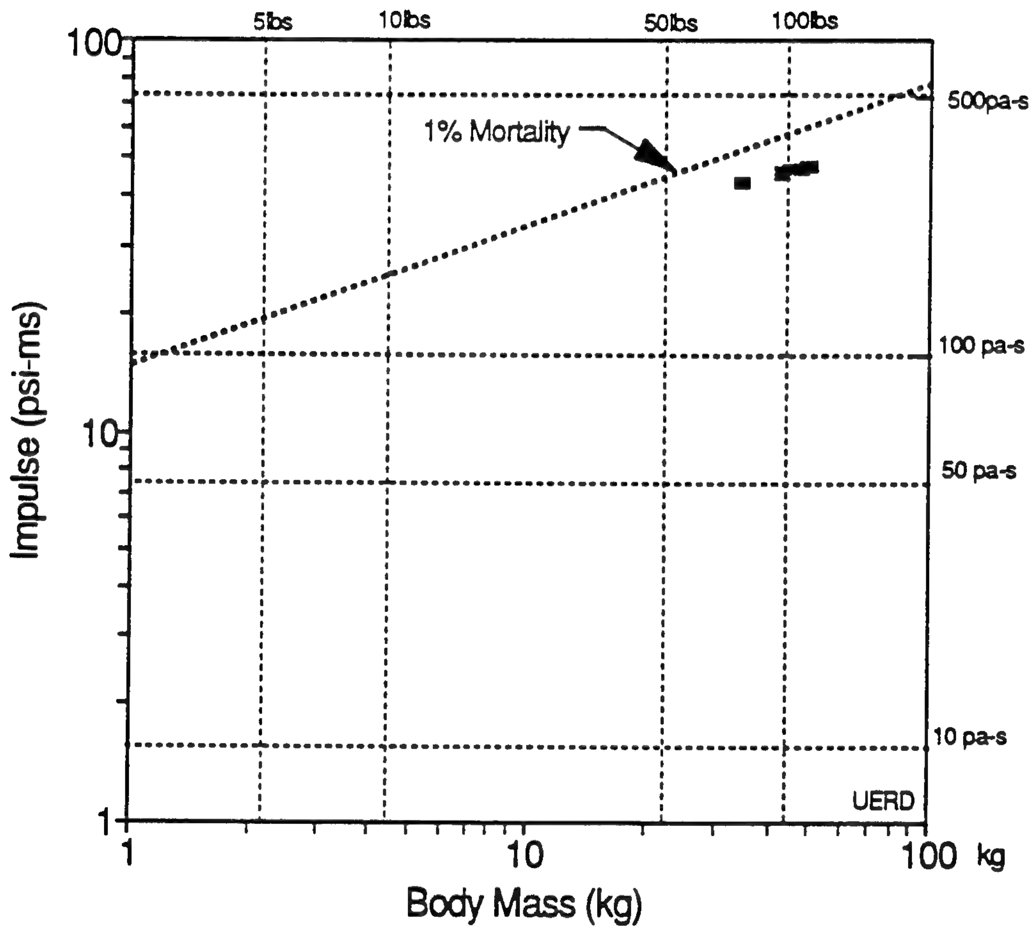
Source: CD-NSWC/UERD

Regression curve values (Yelverton, 1981) indicate that for the range of body weights (masses) of 75 to 110-lb (34 to 50-kg) the "1% Mortality" impulses would be expected to range from 51.9 to 60.2 psi-msec (354 to 410 Pa-sec). Predictions for onset of extensive lung hemorrhage based on actual test conditions using the Goertner model indexed to 42 psi-msec (286.2 Pa-sec) for a 75-lb (34-kg) mammal range from 43.5 to 48.2 psi-msec (296 to 328 Pa-sec).

Figure 4 presents a comparison between the impulses based on the Yelverton (1981) 1% Mortality regression curve and the model predictions from Table 2. In order for the onset of extensive lung injury model to be conservative, the predicted impulse values must be no greater than either the test values or the regression curve values, and the predicted ranges must be no less than the test values.

As can be seen in Table 2 and Figure 4, these conditions are met by the onset of extensive lung injury model. The predicted onset of extensive lung hemorrhage can be used as a conservative index for onset of mortality (1%). (Because of the possible extreme combinations of very small charges and large to extremely large mammals, the onset of extensive lung injury model would not always apply. The extreme short ranges and resultant high peak shockwave pressures become indicative of external tissue damage and associated injuries.[3] The onset of extensive lung injury model is

[3] External tissue damage to marine mammals is discussed in Section B.2.2.



Source: Yelverton (1981), CD-NSWC/UERD

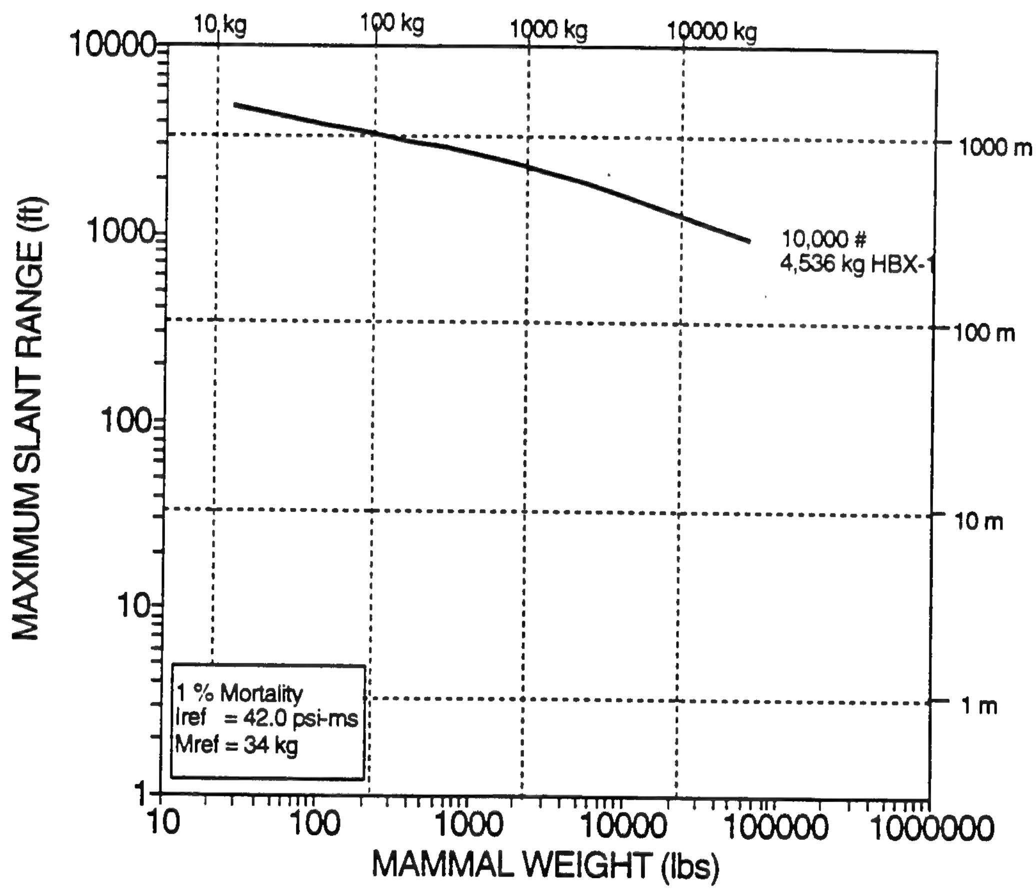
Figure 4. Comparison of Predicted 1% Mortality and Calculated Onset of Extensive Lung Hemorrhage Impulses.

therefore limited to ranges and impulses where the peak shockwave pressure is less than 1400 psi [9.7 MPa]).

Figure 5 presents maximum calculated slant ranges for the onset of extensive lung hemorrhage as a function of mammal weight for the 10,000-lb (4536-kg) charge. Charge and mammal depths have been varied so that the ranges shown in Figure 5 are conservative for any depths. Extensive lung hemorrhage is an injury which would be debilitating and not all animals would be expected to survive (1% mortality).

Based on pathology reports (Richmond, et. al., 1973), G.I. tract injuries associated with the onset of extensive lung hemorrhage would include contusions with no ulcerations. As the severity of extensive lung hemorrhage increases beyond the onset level, G.I. tract injuries can increase significantly to include contusions with ulcerations throughout the entire G.I. tract and ultimately to include ruptures of the G.I. tract. The expected mortality level associated with these combined severe injuries would be significantly higher than 1%.

Based on the Yelverton (1981) 50% Mortality regression curve, impulses sufficient for 50% mortality range from 79.9 to 92.7 psi-msec (545 to 632 Pa-sec) for the range of body weights (masses) of 75 to 110-lb (34 to 50-kg). Referring to Table 2 it can be seen that the first six rows of test data have values near or within the



Source: CD-NSWC/UERD

Figure 5. Maximum Calculated Ranges for 1% Mortality (Onset of Extensive Lung Hemorrhage) as a Function of Mammal Weight for a 10,000-lb (4536-kg) Charge.

Yelverton 50% Mortality requirements. Table 3 presents a comparison of test data (Richmond, et al., 1973) and Goertner model predictions. For occurrence of extensive lung hemorrhage, the Goertner model was indexed to 83.4 psi-msec (568.4 Pa-sec) for a 95-lb (43-kg) mammal, or:

$$I_{50\%} = 83.4\ (M/43)^{1/3}\ \text{psi-msec}$$

and

$$I_{50\%} = 568.4\ (M/43)^{1/3}\ \text{Pa-sec},$$

where M is the body mass (in kg) of the subject animal and $I_{50\%}$ is impulse for 50% mortality.

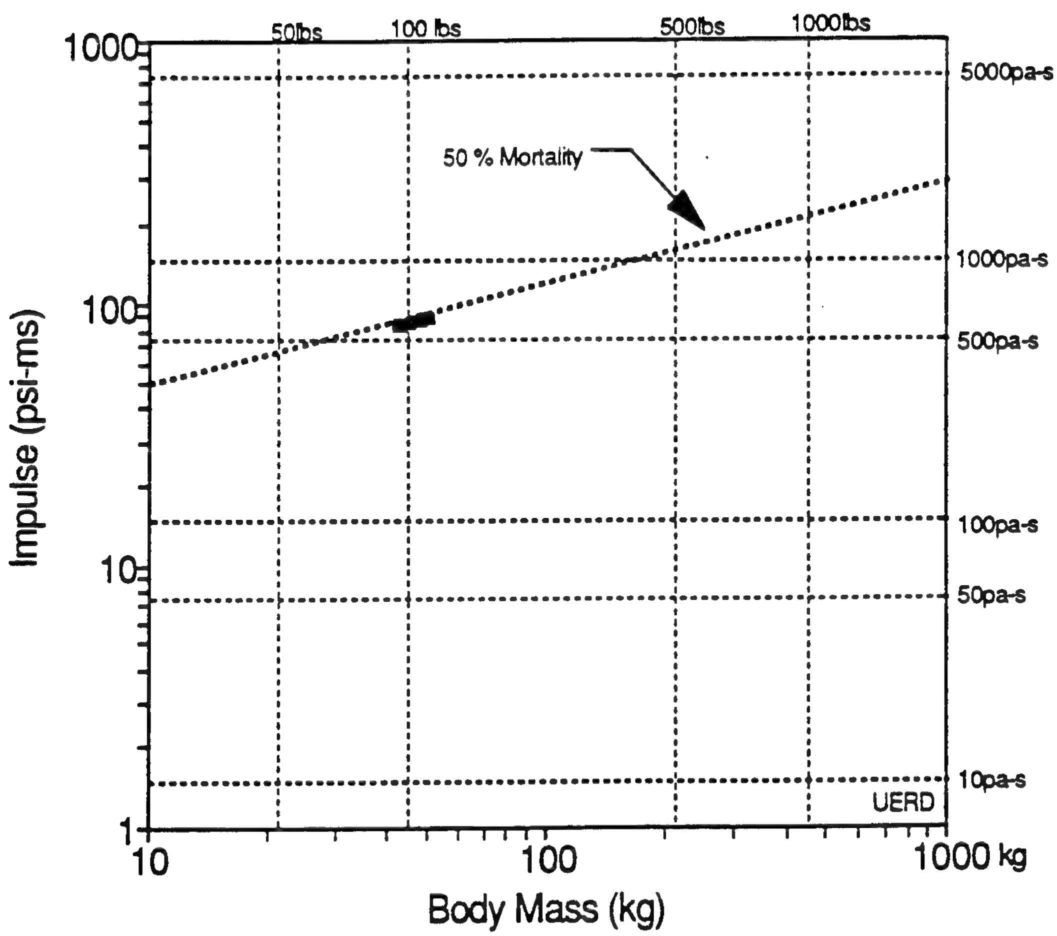
Figure 6 presents a comparison between the impulses based on the Yelverton (1981) 50% Mortality curve and the model predictions from Table 3. The extensive lung hemorrhage calculations are in good agreement with the test data and the Yelverton 50% Mortality regression curve. The predicted impulse values are less than the regression curve values and the predicted ranges are slightly greater than the test values. The range and impulse values predicted for the occurrence of extensive lung hemorrhage and its attendant severe to extensive G.I. tract injuries can be used as an index for 50% mortality.

Table 3. Extensive Lung Hemorrhage (50% Mortality) Model Verification.

EXPLOSIVE (Pentolite)		MAMMAL		TEST DATA[1]			MODEL PREDICTIONS[2]		
WEIGHT lb/(kg)	DEPTH ft/(m)	BODY MASS lb/(kg)	DEPTH ft/(m)	RANGE ft/(m)	PEAK PRESSURE psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)	RANGE ft/(m)	PEAK PRESSURE[3] psi/(kPa)	IMPULSE psi-msec/ (Pa-sec)
1.052 (0.48)	10.0 (3.0)	95 (43)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1072 (7306)	84.1 (573)
1.052 (0.48)	10.0 (3.0)	106 (48)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1105 (7531)	87.3 (595)
1.052 (0.48)	10.0 (3.0)	110 (50)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1117 (7612)	88.5 (603)
1.052 (0.48)	10.0 (3.0)	108 (49)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1111 (7571)	87.9 (599)
1.052 (0.48)	10.0 (3.0)	95 (43)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	17 (5.2)	875 (5963)	84.9 (579)
1.052 (0.48)	10.0 (3.0)	99 (45)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	17 (5.2)	887 (6045)	86.2 (587)

1 Occurrence of Extensive Lung Hemorrhage (Richmond, et al., 1973)
2 Extensive Lung Hemorrhage (after Goertner, 1982)
3 Weak Shock Theory (Gaspin, 1983)

Source: CD-NSWC/UERD



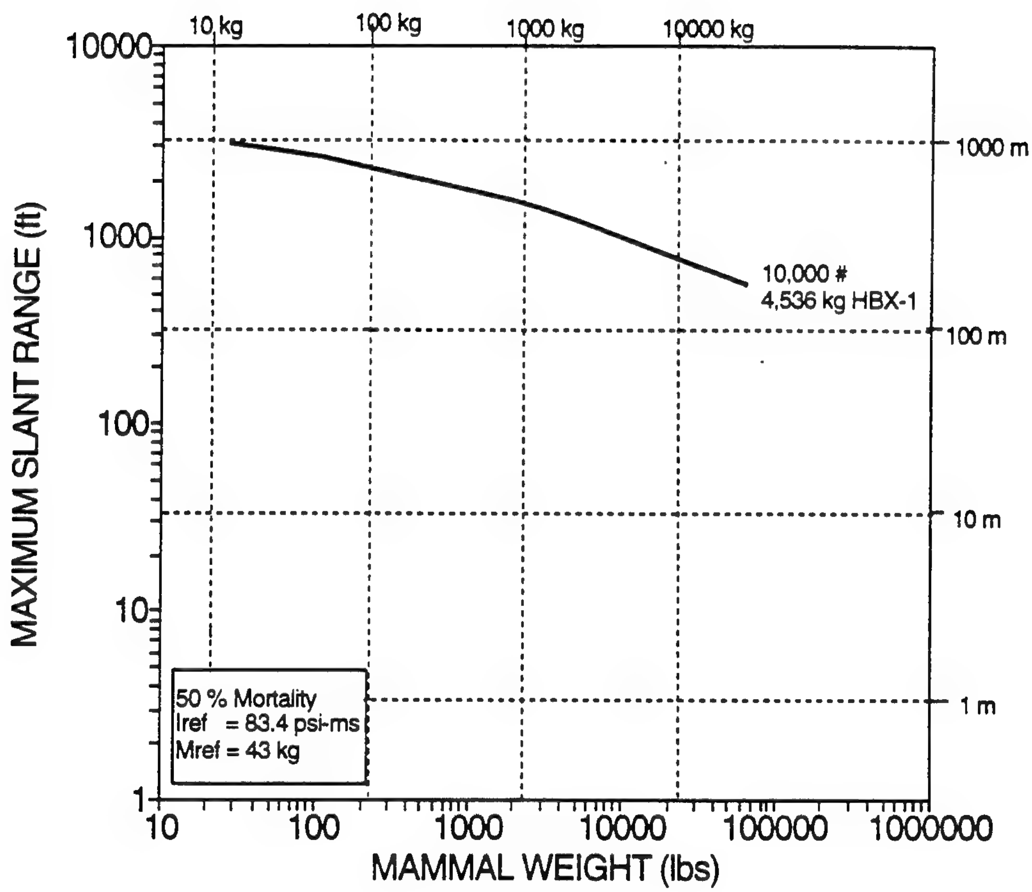
Source: Yelverton (1981), CD-NSWC/UERD

Figure 6. Comparison of Predicted 50% Mortality and Calculated Extensive Lung Hemorrhage Impulses.

Figure 7 presents maximum calculated slant ranges for the occurrence of 50% mortality (extensive lung hemorrhage) as a function of mammal weight for a 10,000-lb (4536-kg) charge. Charge and mammal depths have been varied so that the ranges shown in Figure 7 are conservative for any depths. (As with the onset of extensive lung injury model, the extensive lung injury model is limited to ranges and impulses where the peak shockwave pressure is less than 1400 psi [9.7 MPa].)

B.2.2. Lethal Injury from Shockwaves with High Peak Pressure

Myrick, et al. (1990) reported on the effects to dolphin carcasses from underwater explosion tests using a 0.15 oz (5.76 gm) "seal bomb". No damage was noted at a detonation distance of 2.3 ft (0.7 m). When the "seal bomb" was detonated 2 ft (0.6 m) away, "... a 5 x 7-cm jagged wound 4-cm deep was incurred above the right shoulder.... Subsequent examination of the carcass disclosed that the right shoulder blade had been shattered, the diaphysis of the humerus fractured, and the subscapular and intercostal musculature pulverized, but no penetration was made into the pulmonary cavity. Examination of the cranial bones revealed fractures to hamular processes of both pterygoids and a fractured left temporal bone. No internal damage was found, except possible evidence of compression on the right lung by the first right rib, thought perhaps to have been associated with the shoulder-blast damage. Participants in the examination of the specimen could not attribute cause of the cranial damage to test explosions partly because the



Source: CD-NSWC/UERD

Figure 7. Maximum Calculated Ranges for 50% Mortality (Extensive Lung Hemorrhage) as a Function of Mammal Weight for a 10,000-lb (4536-kg) Charge.

temporal fracture was on the side opposite the shoulder damage. Further, there was no certainty that the cranial damage was not incurred elsewhere since postmortem history of the specimen was unknown," (Myrick, et al., 1990).

Assuming the "seal bomb" to have a 90% TNT equivalence, the calculated peak shockwave pressures are 1451 psi (10.0 MPa) at a distance of 2.3 ft (0.7 m), and 1711 psi (11.8 MPa) at a distance of 2 ft (0.6 m). Animals exposed to shockwave pressures of these magnitudes, regardless of the charge size or animal body weight, will be subjected to extremely high impulse levels. Depending upon the size of the animal, these impulse levels may or may not be lethally injurious to the animals' internal organs; however, shock and significant external tissue damage as well as possible damage to the skeletal system would be expected. Animals suffering these types of injuries would also likely be at increased risk of disease and predation. All internal organ injury models utilized in this document use the 1400 psi (9.7 MPa) peak shockwave pressure as a limiting value. Animals exposed to peak shockwave pressures in excess of 1400 psi (9.7 MPa) would be considered lethally injured.

B.3. Auditory System Injury

Eardrum damage criteria are based on a limited number of small charge tests as reported by both Yelverton, et al. (1973) and Richmond, et al. (1973). Eardrum-specific tests were conducted with dogs using nominal 1-lb (0.45-kg) TNT

charges. Additional eardrum data from general injury tests conducted with sheep using nominal 0.5-lb and 1-lb (0.23-kg and 0.45-kg) pentolite charges are also included in order to develop a conservative eardrum damage model. The test conditions and results from Richmond, et al. (1973) are provided in Table 4. Since the purpose of developing an eardrum damage model is to conservatively predict damage (percent rupture) based on actual data, the model development will be based on actual test geometries, actual minimum charge weights, and worst case results. The model will utilize calculated shockwave parameters to tie in test data to computations. Seven of the eleven test groups were conducted with only three subjects; two with six subjects; and two with twelve subjects. In some instances, eardrums were not accessible or readable following a test. These cases are counted as possible ruptures for the eardrum damage model development. To simplify the analysis, only eardrums directly facing the blast are used. Eardrums facing away from the blast were potentially subjected to significantly different shockwave loading than those directly facing the blast. Additionally, eardrums facing away from the blast may have been damaged by later-occurring intra-cranial pressures and/or cranial trauma rather than by directly measurable or readily calculable shockwave parameters. Handling and submergence tests conducted with control animals not subjected to explosions did not cause any eardrum ruptures.

Table 4. Eardrum Damage Test Conditions and Results.

DATA SET	EXPLOSIVE[1]		RANGE	PEAK PRESSURE[2]	TOTAL IMPULSE[2]	TOTAL ENERGY[2]	EARDRUMS[3]		NO. RUPTURED	% RUPTURED
	Type	Weight lb / (kg)	ft / (m)	psi / (kPa)	psi-msec / (Pa-sec)	in-lb/in² / (milli-Joules/cm²)	No.	depth ft / (m)		
1	TNT	1.047 (0.47)	20 (6.1)	672 (4580)	59.4 (405)	4.244 (74.34)	3	1 (0.3)	3	100
2	TNT	1.047 (0.47)	40 (12.2)	306 (2085)	21.2 (144)	0.854 (14.96)	12	1 (0.3)	4 - 5[4]	33 - 42[4]
3	TNT	1.047 (0.47)	45 (13.7)	269 (1833)	17.3 (118)	0.637 (11.16)	6	1 (0.3)	0	0
4	TNT	1.047 (0.47)	60 (18.3)	195 (1329)	10.5 (71)	0.301 (5.27)	3	1 (0.3)	0	0
5	PENTOLITE	1.047 (0.47)	33 (10.1)	401 (2733)	44.4 (303)	1.912 (33.49)	3	2 (0.6)	2	67
6	PENTOLITE	1.047 (0.47)	54 (16.5)	232 (1581)	22.2 (151)	0.653 (11.44)	3	2 (0.6)	0	0
7	PENTOLITE	1.047 (0.47)	83 (253)	145 (988)	10.9 (74)	0.228 (3.99)	3	2 (0.6)	0	0
8	PENTOLITE	1.047 (0.47)	48 (14.6)	264 (1799)	37.4 (255)	0.931 (16.31)	3	10 (3.0)	0	0
9	PENTOLITE	1.047 (0.47)	84 (25.6)	143 (975)	22.3 (152)	0.313 (5.48)	6	10 (3.0)	0 - 1[4]	0 - 17[4]
10	PENTOLITE	0.485 (0.22)	93 (28.3)	97 (661)	6.9 (47)	0.093 (1.63)	3	2 (0.6)	0	0
11	PENTOLITE	0.485 (0.22)	100 (30.5)	89 (607)	12.0 (82)	0.106 (1.86)	12	10 (3.0)	1	8

1 Minimum charge weights; all tests conducted with charge at 10 ft (3.0 m) depth.
2 Calculated values.
3 Eardrums facing the charge.
4 Not all eardrums were accessible or readable following a test; the second value given presumes that these eardrums were ruptured.

Source: Richmond, et al. (1973); CD-NSWC/UERD

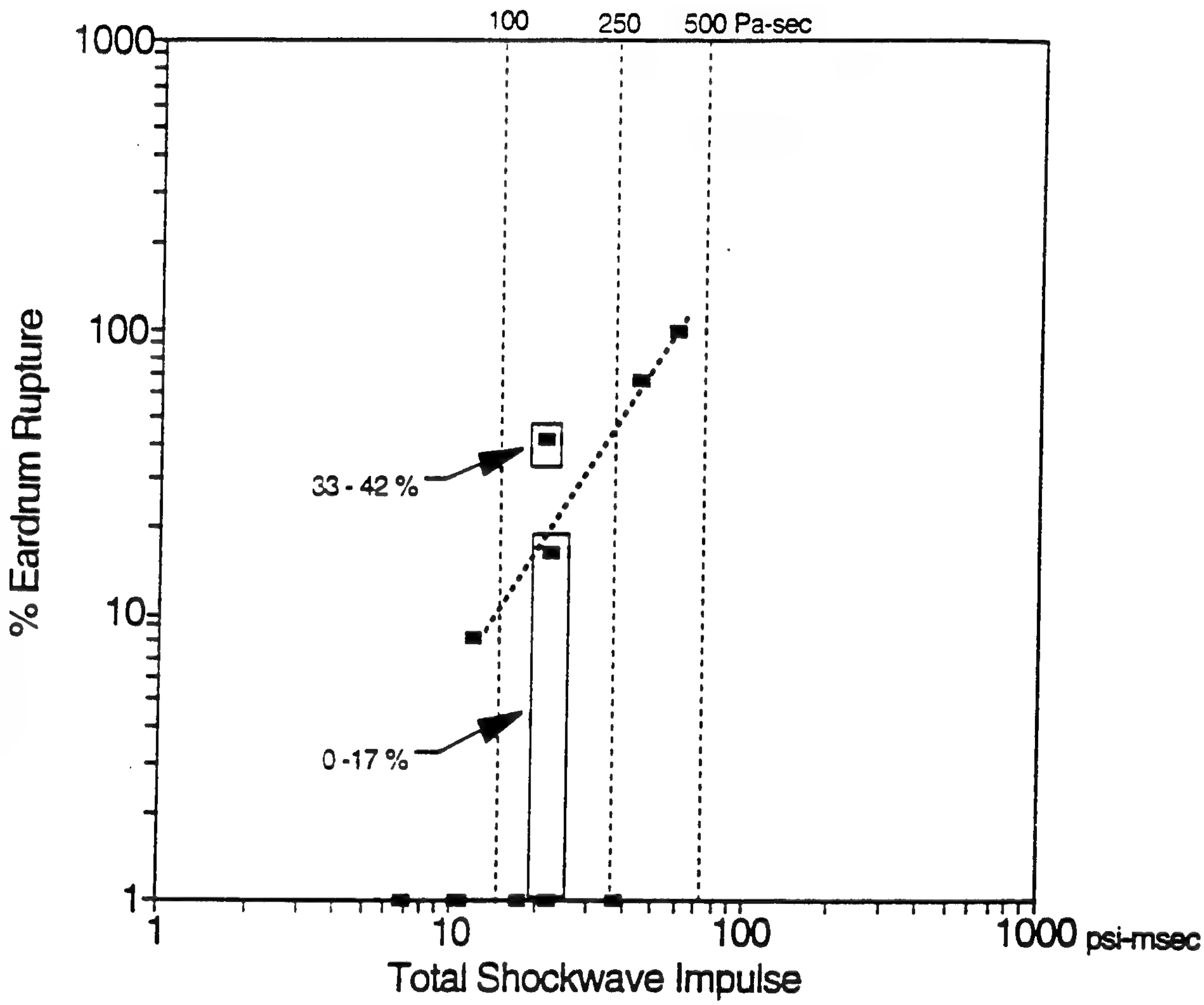
Damage to mammal organs has typically been referenced to total shockwave impulse--both Richmond, et al. (1973) and Yelverton, et al. (1973) referenced eardrum rupture to total shockwave impulse. Figure 8 shows percentage of eardrum ruptures as a function of calculated total shockwave impulse using data sets 1, 2, 5, 9, and 11 from Table 4. It can be seen that total shockwave impulse is a general indicator of the possibility of eardrum rupture.

Figure 9 is percent eardrum rupture as a function of calculated total shockwave energy using the calculated values from Table 4. The upper bound for percentages of eardrums ruptured and the computed energy values from data sets 2, 5, 9, and 11 fall reasonably into place along an exponential curve. Data set 1 was excluded since the energy value may well have been in excess of the minimum energy required for 100% rupture.

Using data sets 5 and 11, the exponential curve in Figure 9 can be conservatively expressed as:

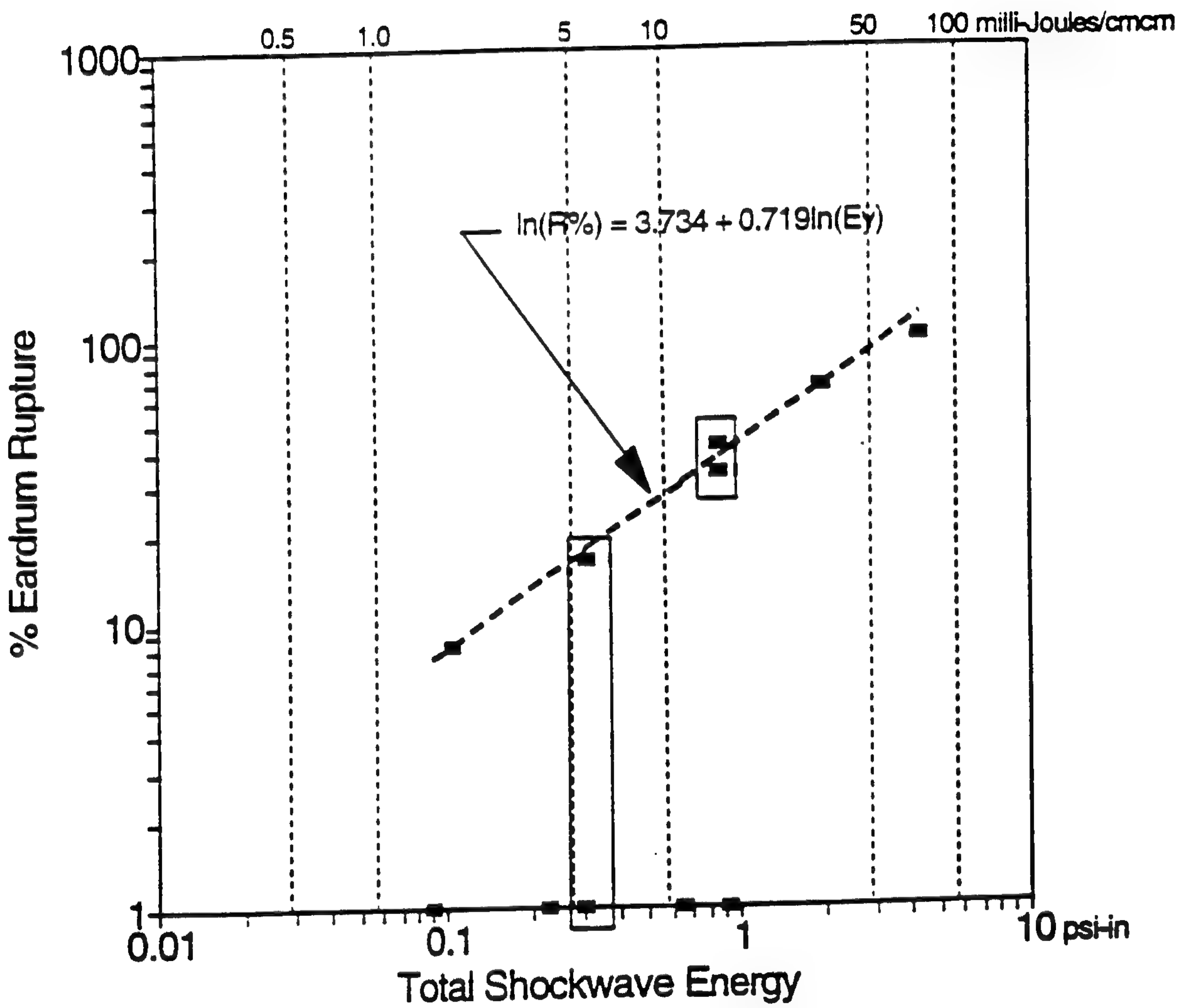
$$\ln R_{\%} = 3.734 + 0.719 \ln E, \qquad (1)$$

where $R_{\%}$ is the maximum percentage of eardrums ruptured and E is the calculated total shockwave energy (in in-lb/in^2). For nominal 0.5-lb to 1-lb (0.23-kg to 0.45-kg) charges at very shallow depths, equation (1) should be more than adequate to



Source: CD-NSWC/UERD after Richmond, et al. (1973) and Yelverton, et al. (1973)

Figure 8. Eardrum Rupture as a Function of Calculated Total Shockwave Impulse.



Source: CD-NSWC/UERD

Figure 9. Eardrum Rupture as a Function of Calculated Total Shockwave Energy.

accurately predict percentages of rupture and/or standoffs for a given rupture percentage. Equation (1) would not be expected to accurately predict eardrum ruptures from larger and/or deeper charges that have shockwaves with significantly larger decay constants and/or longer durations when compared with the test data.

Table 5 provides calculated shockwave pressures and incremental energies for data sets 1, 2, 5, 9, and 11 in 0.10 msec increments from shockwave arrival to surface cut-off time. Using data sets 5, 9, and 11 from Table 5, an iterated numerical solution can be achieved for the percentage of eardrums ruptured as a function of incremental shockwave energy. The equations to be solved have the form:

$$a(1.00) + b(1.00\text{-}a) + c[(1.00\text{-}a)\text{-}b(1.00\text{-}a)] +$$
$$d\{(1.00\text{-}a)\text{-}b(1.00\text{-}a)\text{-}c[(1.00\text{-}a)\text{-}b(1.00\text{-}a)]\} + \ldots = R_{\%}/100,$$

where a, b, c, d are percentages (divided by 100) of eardrums ruptured at 0.10, 0.20, 0.30, 0.40 msec, respectively, and $R_{\%}$ is the total percentage of eardrums ruptured for the total composite shockwave. The iterated approximate numerical solutions for data sets 5, 9, and 11 are provided in Table 6 and plotted in Figure 10.

The exponential curve from Figure 10 can be conservatively described by:

$$\ln R_{\%} = 3.778 + 0.767 \ln E_I \,, \qquad (2)$$

Table 5. Calculated Shockwave Pressures and Incremental Energies.

DATA SET*	TIME (msec)	PRESSURE psi	(kPa)	INCREMENTAL ENERGY in-lb/in²	(milli-Joules/cm²)	RUPTURES (%)
1	0.000	672	(4580)	0.000	--	100.0
	0.100	252	(1717)	3.712	(65.02)	
	0.200	95	(647)	0.522	(9.14)	
	0.206	89	(606)	0.010	(0.18)	
2	0.000	306	(2085)	0.000	--	33.3-41.6
	0.100	129	(879)	0.839	(14.69)	
	0.105	124	(845)	0.014	(0.25)	
5	0.000	401	(2733)	0.000	--	66.7
	0.100	185	(1261)	1.538	(26.94)	
	0.200	85	(579)	0.326	(5.71)	
	0.251	57	(388)	0.048	(0.84)	
9	0.000	143	(975)	0.000	--	0-16.7
	0.100	78	(532)	0.221	(3.87)	
	0.200	42	(286)	0.065	(1.14)	
	0.300	23	(157)	0.020	(0.35)	
	0.400	13	(89)	0.005	(0.09)	
	0.494	7	(48)	0.002	(0.04)	
11	0.000	89	(607)	0.000	--	8.3
	0.100	44	(300)	0.080	(1.40)	
	0.200	22	(150)	0.020	(0.35)	
	0.300	11	(75)	0.005	(0.09)	
	0.400	5	(34)	0.001	(0.02)	
	0.417	5	(34)	0.000	(0)	

* From Table 4

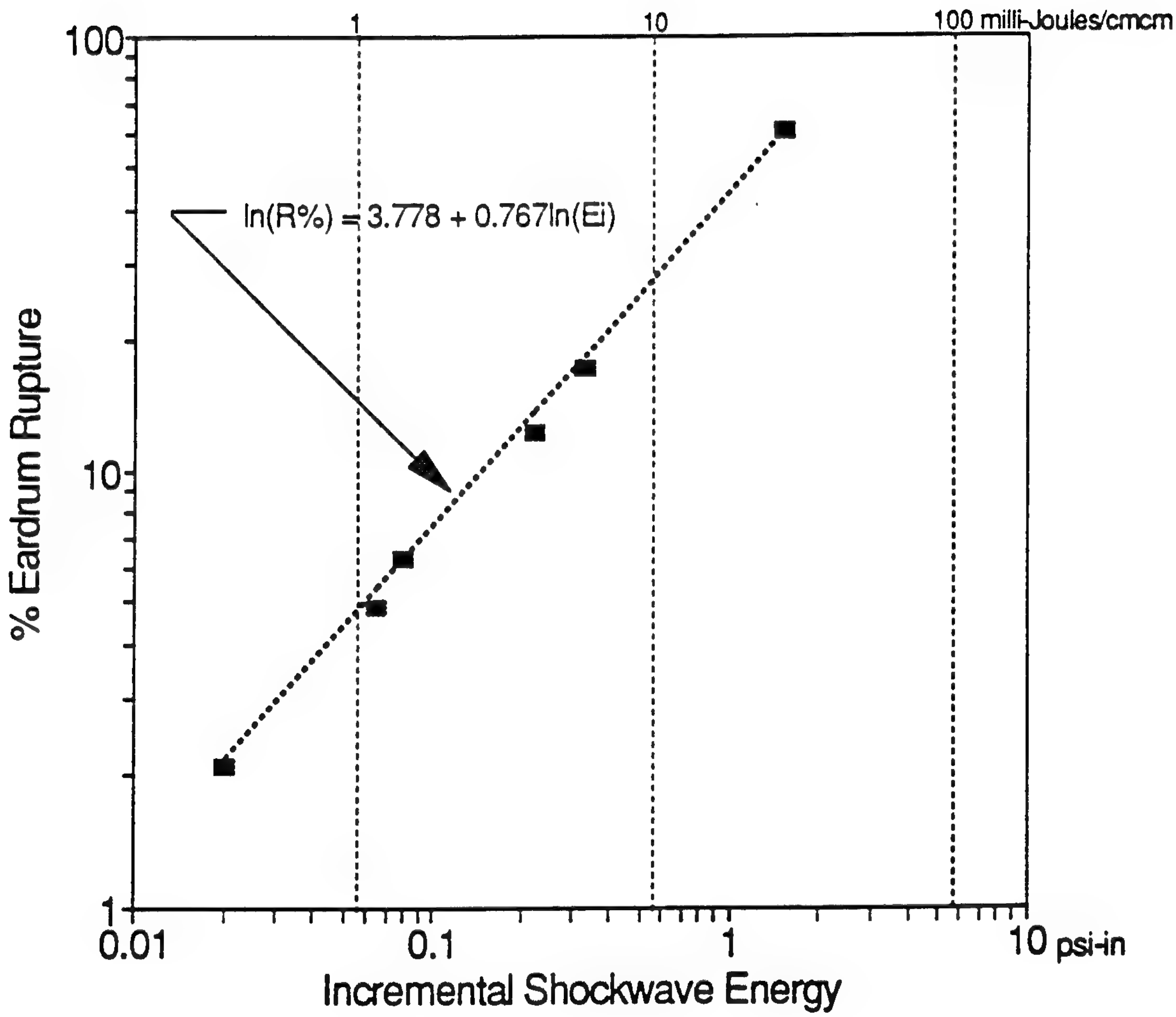
Source: CD-NSWC/UERD

Table 6. Calculated Percentage of Eardrum Ruptures for Discrete Values of Calculated Shockwave Energy.

INCREMENTAL ENERGY, E in-lb/in^2	(milli-Joules/cm^2)	DATA SET[1]	RUPTURE PERCENTAGE
0.020	(0.35)	9, 11	2.1
0.065	(1.14)	9	4.9
0.080	(1.40)	11	6.3
0.221	(3.87)	9	12.4
0.326	(5.71)	5	17.5
1.538	(26.93)	5	60.8

[1] From Table 4

where $R_{\%}$ is the incremental rupture percentage and E_i is the incremental shockwave energy. Equation (2) is used by breaking down a shockwave into 0.10 msec increments and computing a rupture percentage--the computed percentage must be applied to the remaining unruptured percentage from all previous iterations. For shockwave increments less than 0.10 msec duration, the computed percentage is multiplied by the ratio of the actual duration to the 0.10 msec increment basis. Table 7 presents the actual and computed rupture percentages and the actual and computed number of ruptures for data sets 1 through 11 using equations (1) and (2). Computations using equation (2) were terminated at surface cutoff time, or when the calculated shockwave pressure dropped below 20 psi (136.3 kPa). As shown in Table 7, predicted eardrum ruptures using either equation (1) or (2) compare very well with the test data. Although there are no large charge data available to verify the



Source: CD-NSWC/UERD

Figure 10. Eardrum Rupture as a Function of Incremental Shockwave Energy.

Table 7. Comparison of Actual and Predicted Terrestrial Mammal Eardrum Ruptures.

DATA SET[1]	SAMPLE SIZE	ACTUAL		PREDICTED[2]		PREDICTED[3]	
		%	NO. OF RUPTURES	%	NO. OF RUPTURES	%	NO. OF RUPTURES
1	3	100	3	100	3	100	3
2	12	33 - 42	4 - 5	37	4	38	5
3	6	0	0	30	2	29	2
4	3	0	0	18	1	12	0
5	3	67	2	67	2	69	2
6	3	0	0	31	1	31	1
7	3	0	0	14	0	7	0
8	3	0	0	40	1	44	1
9	6	0 - 17	0 - 1	18	1	21	1
10	3	0	0	9	0	6	0
11	12	8	1	8	1	9	1

[1] From Table 4
[2] Using equation (1)
[3] Using equation (2)

applicability of either equation to large charge tests, equation (2) should be used as a conservative predictive tool for estimating eardrum ruptures for charge weights and charge depths that are outside the range of the original test data.

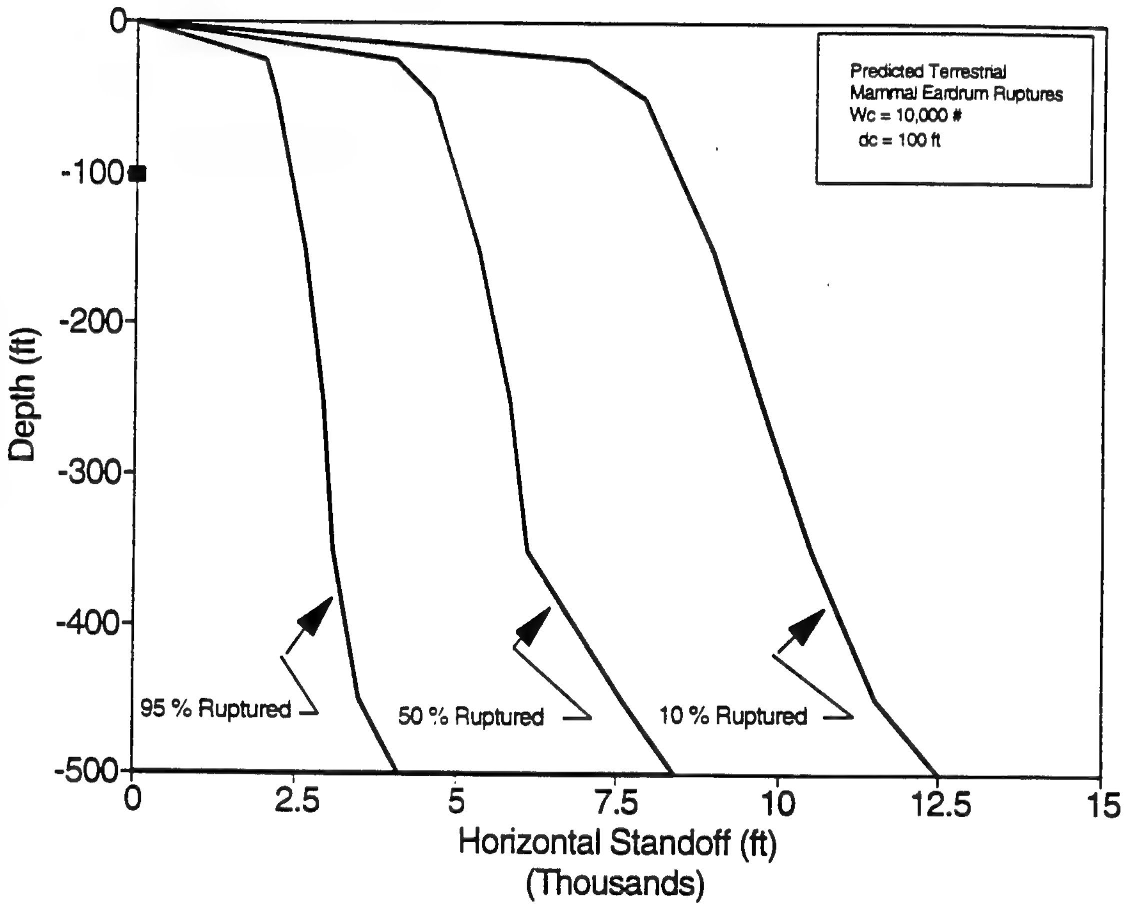
Table 8 provides the range of predicted standoffs for 95%, 50%, and 10% terrestrial mammal eardrum rupture for the 10,000-lb (4536-kg) charge using equation (2). Figure 11 shows the calculated 95/50/10 percent terrestrial mammal eardrum rupture contours.

Table 8. Predicted Ranges for Terrestrial Mammal Eardrum Rupture for a 10,000-lb (4536-kg) Charge[1].

MAMMAL DEPTH	95% RUPTURE RANGE	50% RUPTURE RANGE	10% RUPTURE RANGE
ft / (m)	ft / (m)[2]	ft / (m)[2]	ft / (m)[2]
50 / (15.2)	2150 / (655.3)	4000 / (1219.2)	7900 / (2407.9)
250 / (76.2)	2900 / (883.9)	5325 / (1623.1)	9750 / (2971.8)
500 / (152.4)	4070 / (1240.5)	8375 / (2552.7)	12,440 / (3791.7)

10,000-lb (4536-kg) at 100-ft (30-m) depth.
Based on incremental shockwave energy (equation 2).

Source: CD-NSWC/UERD



Source: CD-NSWC/UERD

Figure 11. Eardrum Rupture Injury Contours for a 10,000-lb (4536-kg) Charge.

B.3.1. Lethality as a Result of Auditory System Injury

Todd, et al. (1993), reporting on the observed impacts of construction project blasting operations on seasonally resident humpback whales, noted that, "Humpback whales showed little behavioral reactions to the detonations, either in terms of decreased residency, resighting rates, or in terms of overall movements or general behavior. However, there seems little doubt that the increased entrapment rates were influenced by the long term effects of exposure to deleterious levels of sound.... Exposure to detonations can at least occasionally have harmful (lethal) effects." (Ketten, et al. [1993] provided a detailed pathological description of the eardrum injuries.)

The construction project differs significantly from the Navy project described in this document:

1. The whales were seasonal residents; marine mammals in the test area are expected to be transients and would probably not be exposed to high sound pressure levels from multiple detonations.

2. The construction project used a 1-nm (1.9 km) safety range for all charge weights -- from sub-1000 kg (2200 lb) to 5500 kg (12,125 lb). The Navy project described in this document will utilize a safety range which exceeds the 1 nm (1.9 km) used for all charge weights during the construction project.

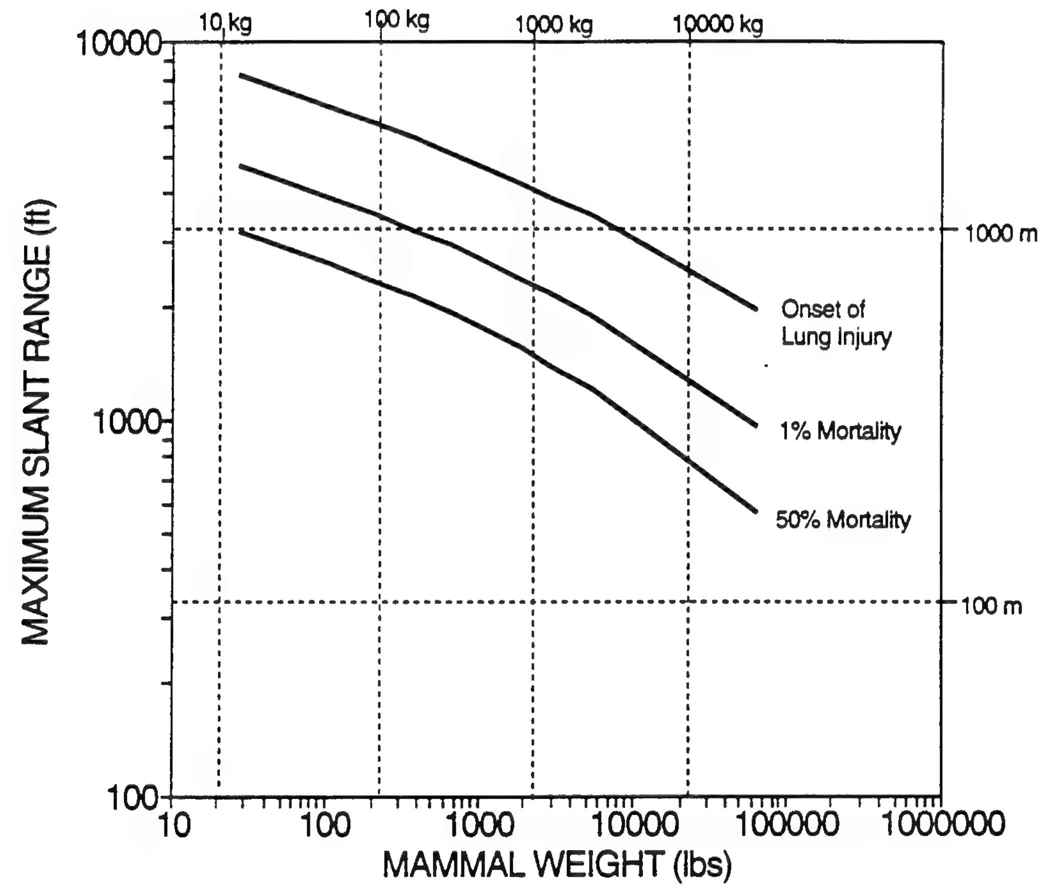
3. The blasting site was Bow Arm - a narrow, shallow fjord with rock sidewalls and a hard reflective bottom. The Navy test site is in ocean waters away from highly reflective side and bottom surfaces.

C. Calculated Injury Ranges for Marine Mammals

"An analysis of the information presented [in A and B] shows that marine mammals are probably less vulnerable to *gross* physical damage from underwater shock waves than are land mammals of comparable size. This is primarily because of adaptations to pressure changes which enable these animals to dive and, secondarily, because of the increased thickness of their body walls. In addition, when marine mammals are diving - particularly when they are deeper than about 150 m [495 ft] - they will probably be less vulnerable than when they are at or near the surface," (Hill, 1978).

Figure 12 combines the onset of lung injury, 1% mortality, and 50% mortality as a function of mammal weight curves from Figures 3, 5, and 7.

Figures 13 through 16 provide calculated range contours for 0% (onset of slight lung hemorrhage), 1% (onset of extensive lung hemorrhage), and 50% (extensive lung hemorrhage) mortalities, for the 10,000-lb (4536-kg) charge for representative cetaceans ranging from 3.3-ft-long/27-lb (1-m/12.2-kg) calf and 8-ft-long/384-lb (2.4-m/174-kg) adult dolphins to 20-ft-long/3110-lb (6.1-m/1410-kg) and 55-ft-long/64,800-lb (16.8-m/29,400-kg) whales. These cetacean sizes were previously used by Goertner (1982) and O'Keeffe and Young (1984) in previous assessments of the potential effects of underwater explosions on marine mammals.



Source: CD-NSWC/UERD, after Goertner (1982); Myrick, et al. (1990)

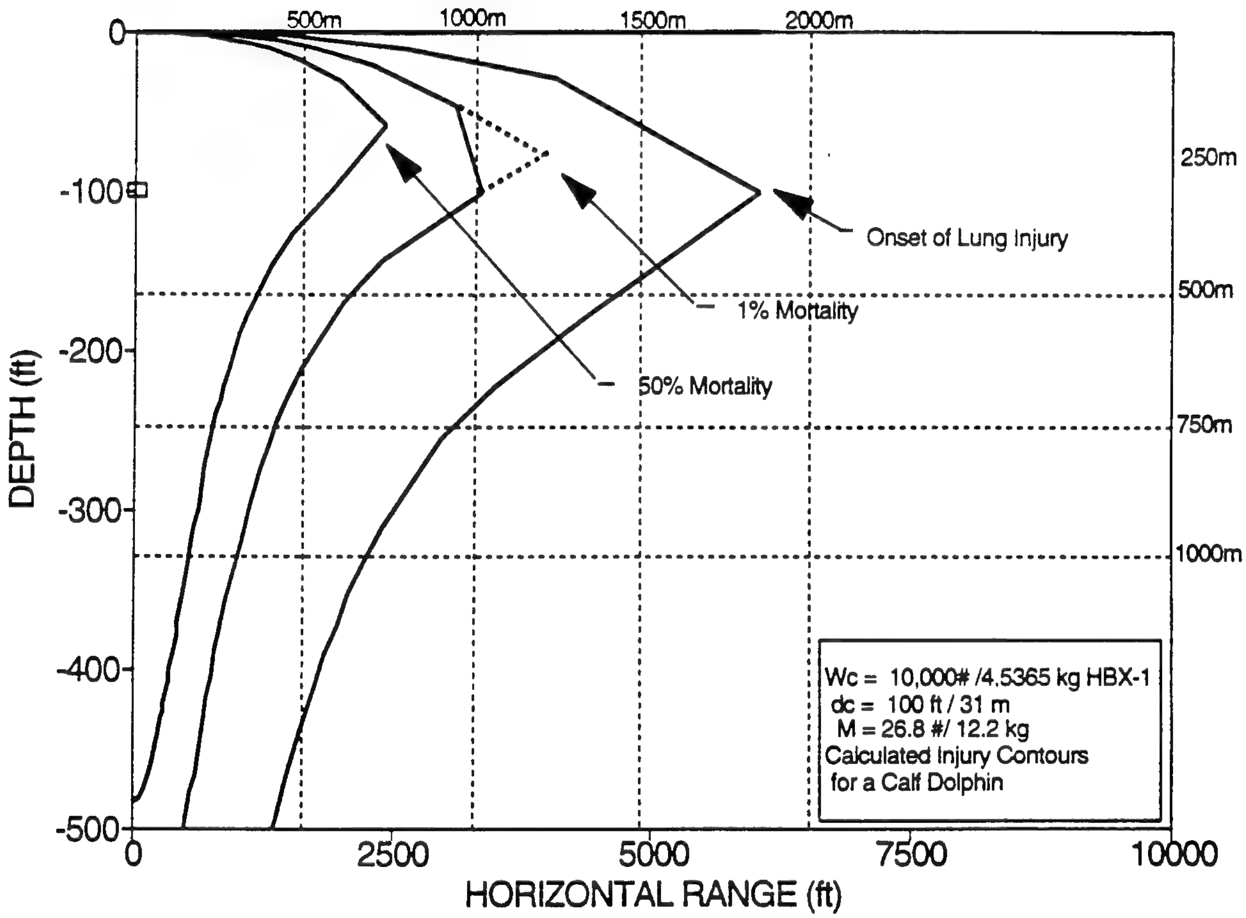
Figure 12. Calculated Injury Ranges as a Function of Mammal Weight for a 10,000-lb (4536-kg) Charge.

The internal organ injury ranges shown in Figures 12 through 16 are based on limited terrestrial animal test data and do not include any reduction for the inherent robustness of marine mammals which should significantly increase their resistance to these types of injuries. On the basis of the best available information, the ranges shown in these figures for internal organ and auditory system injuries are believed to be conservative. It should be noted that the mysticetes, because of their large body mass, should be significantly more resistant to internal organ injuries than to auditory system injury; i.e., baleen whales could be at a relatively high degree of risk for auditory system injury while at a very low degree of risk for injury to internal organs. The assumptions and calculations performed in this study would appear to be supportable by the data and observations of Todd, et al. (1993).

D. Potential Harassment from Underwater Explosions

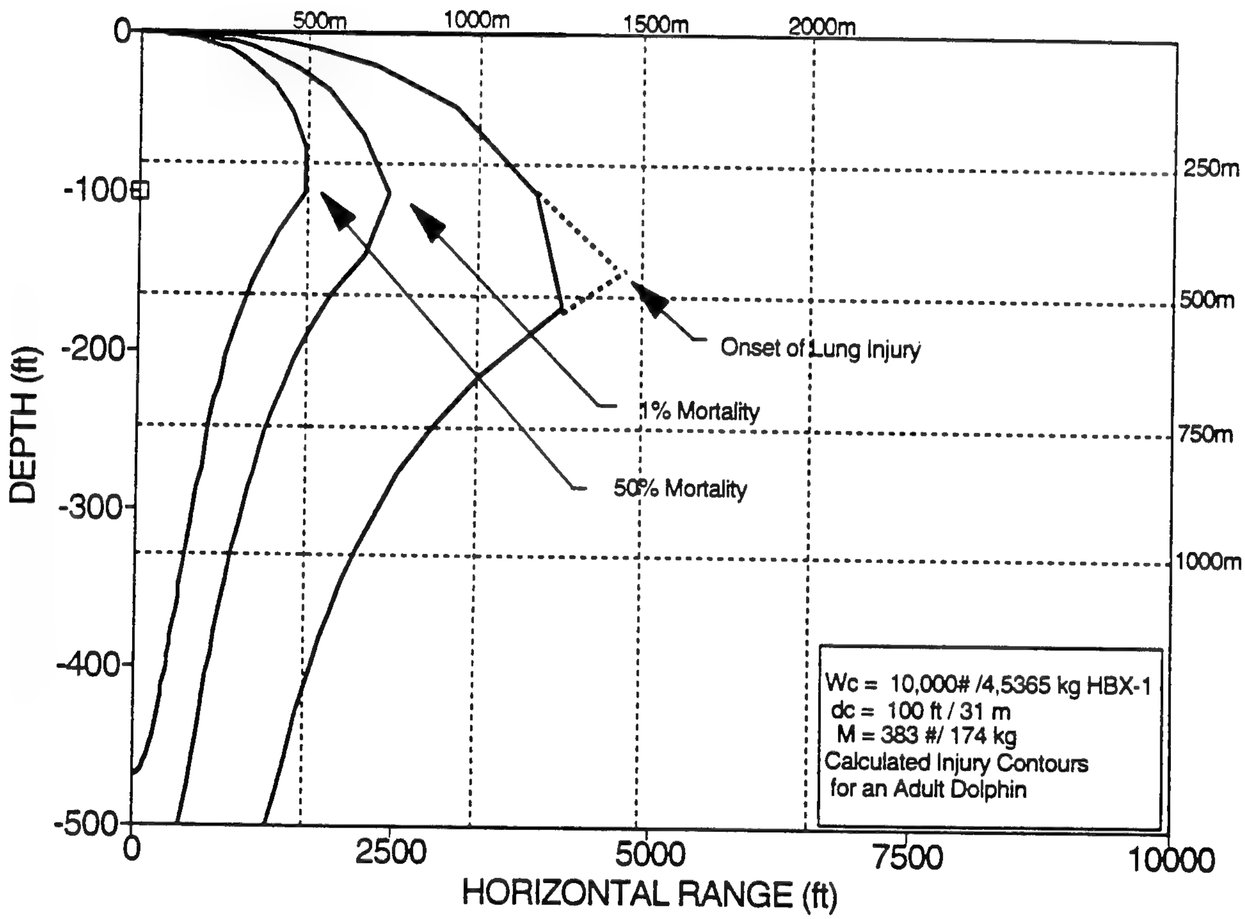
Harassment of marine mammals is defined in the Marine Mammal Protection Act (MMPA), 16 U.S.C. 1362 (as amended, Public Law 103-238, 108 Stat. 532, 557 [1994]), as "any act of pursuit, torment or annoyance which -

(i) has the potential to injure a marine mammal or marine mammal stock in the wild; or



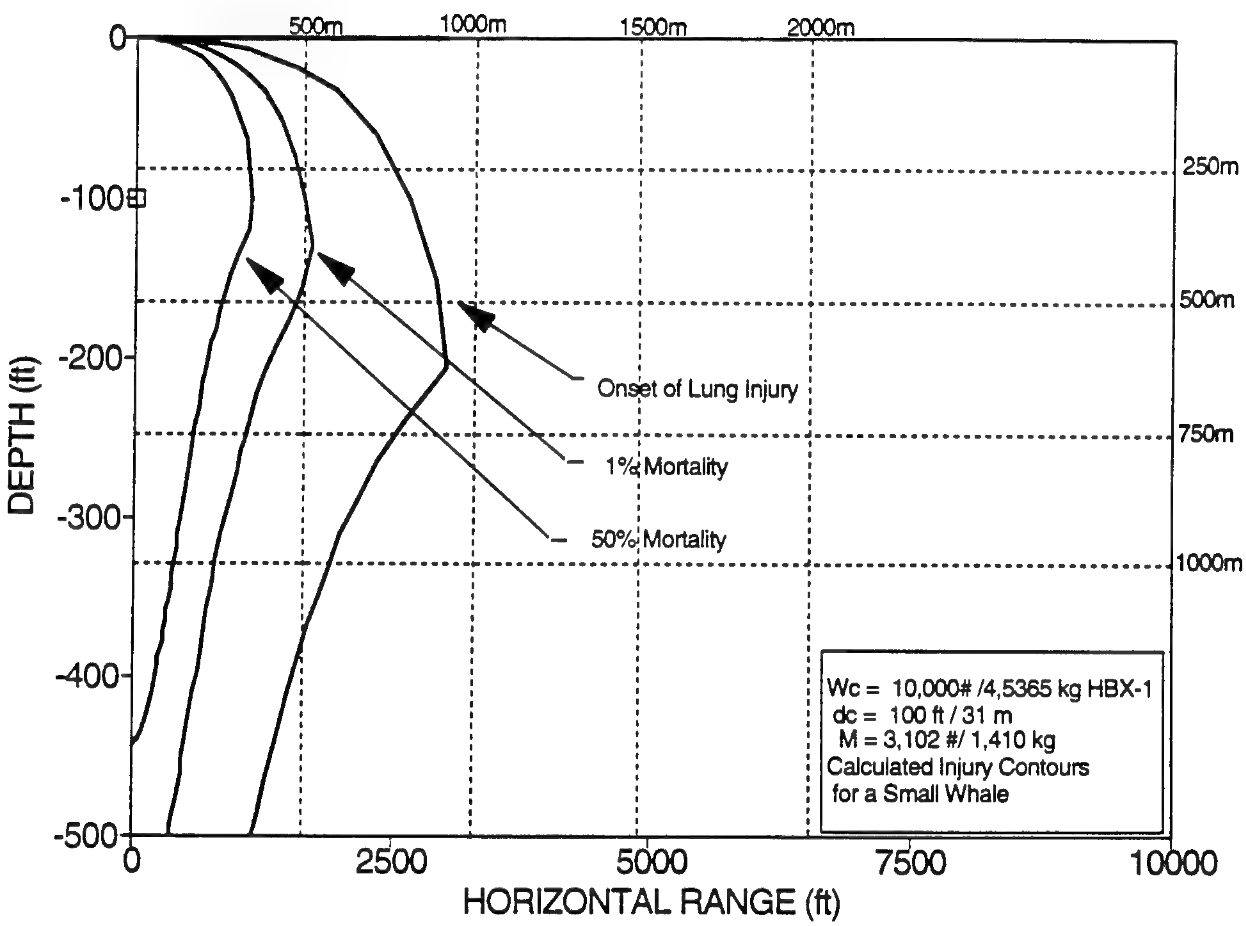
Source: CD-NSWC/UERD, after Goertner (1982), Richmond, et al. (1973), and Yelverton (1981)

Figure 13. Calculated Injury Contours for a Calf Dolphin from a 10,000-lb (4536-kg) Charge.



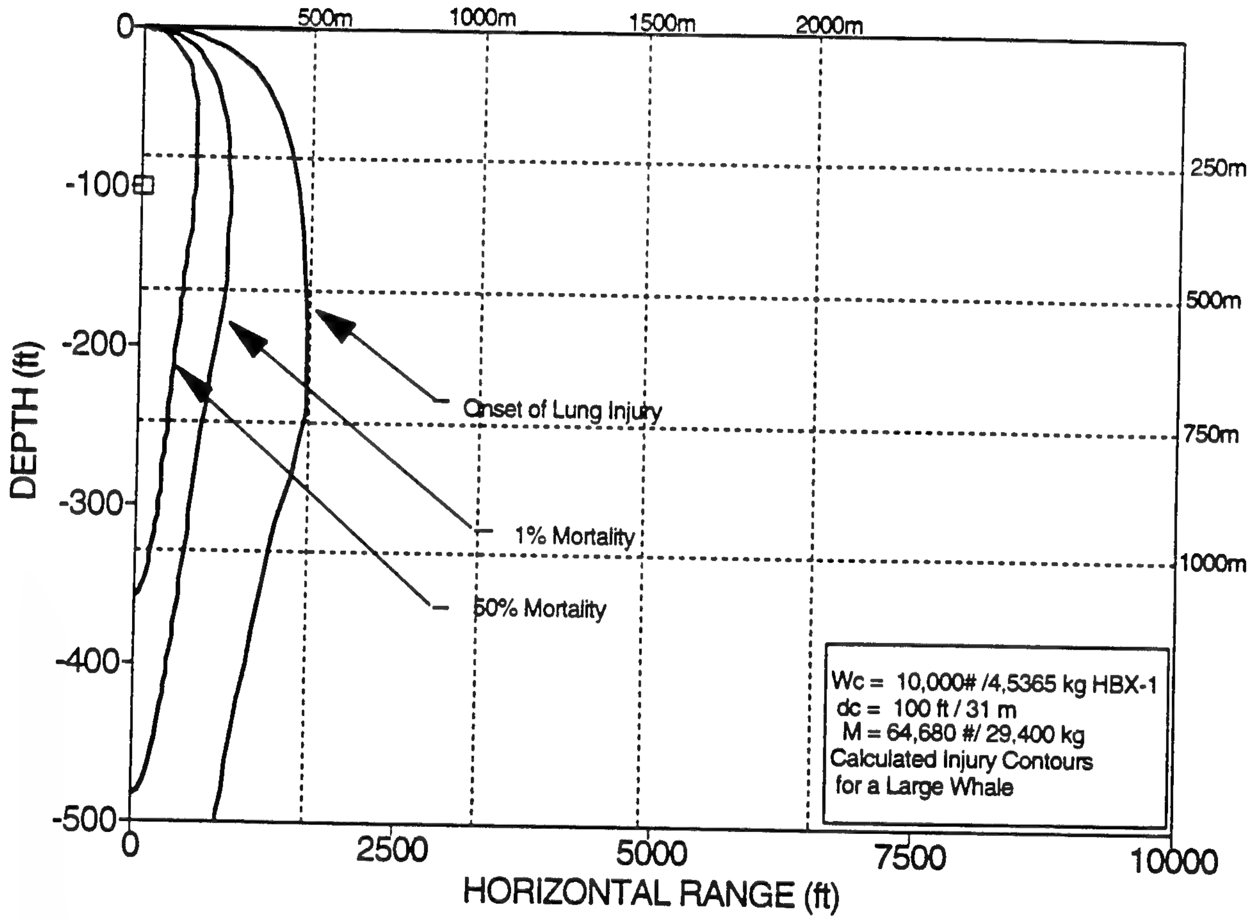
Source: CD-NSWC/UERD, after Goertner (1982), Richmond, et al. (1973), and Yelverton (1981)

Figure 14. Calculated Injury Contours for an Adult Dolphin from a 10,000-lb (4536-kg) Charge.



Source: CD-NSWC/UERD, after Goertner (1982), Richmond, et al. (1973), and Yelverton (1981)

Figure 15. Calculated Injury Contours for a Small Whale from a 10,000-lb (4536-kg) Charge.



Source: CD-NSWC/UERD, after Goertner (1982), Richmond, et al. (1973), and Yelverton (1981)

Figure 16. Calculated Injury Contours for a Large Whale from a 10,000-lb (4536-kg) Charge.

(ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

"Level A harassment" means harassment described in paragraph (i) above and the term "Level B harassment" means harassment described in paragraph (ii) above.

Harassment of marine mammals is similarly defined in the Endangered Species Act (ESA), 16 U.S.C. 1531 to 1544 as "an intentional act or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering."

D.1. Physical Discomfort/Tactile Perception

Occurrence of brief physical discomfort to cetaceans from the shockwave is inferred from data on voluntary human subjects exposed to the shockwave from a 1-lb (0.45-kg) pentolite charge and a 300-lb (136-kg) TNT charge (Christian and Gaspin, 1974). "This inference seems plausible given studies on dolphin skin sensitivity where the authors concluded that the most sensitive areas of the dolphin skin (mouth, eyes, snout, melon, and blowhole) are about as sensitive as the skin of the human lips and fingers (Ridgway and Carder, 1990 and 1993).

Overall skin sensitivity of dolphins equals that of humans (Ridgway and Carder, 1993). Skin sensitivity for... large whales has not been tested," (Moore, 1993).

Exposed to the shockwave from the 1-lb (0.45-kg) charge, human subjects reported feeling no stings or pressure at a 120-ft (36.6-m) range [3.0 psi-msec (20.4 Pa-sec) impulse and 96 psi (654 kPa) peak pressure]; feeling moderate stings at a 115-ft (35.1-m) range [3.3 psi-msec (22.5 Pa-sec) impulse and 98 psi (668 kPa) peak pressure]; and feeling strong stings at a 100-ft (30.5-m) range [4.2 psi-msec (28.6 Pa-sec) impulse and 115 psi (784 kPa) peak pressure]. Shockwave durations were 0.033, 0.035, and 0.040 msec; and calculated energy flux densities were 0.06, 0.06, and 0.08 in-lb/in^2 (1.1, 1.1, and 1.4 milli-Joules/cm^2), respectively. Exposed to the shockwave from the 300-lb (136-kg) charge at a 4050-ft (1235-m) range, human subjects heard "a muffled 'thud' or rumbling.... No sensation of pressure on the body was experienced by any of the four divers..." (Christian and Gaspin, 1974). Calculated shockwave parameters for the 300-lb (136-kg) test include an impulse of 1.9 psi-msec (12.9 Pa-sec), shockwave energy of 0.005 in-lb/in^2 (0.09 milli-Joules/cm^2) and a 17 psi (116 kPa) peak shockwave pressure. The shockwave duration was 0.12 msec.

Physical discomfort resulting from shockwaves from large charges do not readily fit the criteria from small charges. Consideration of partial impulse, energy flux density and peak shockwave pressure are used to assess the potential for

occurrence of physical discomfort. Brief physical discomfort is likely to occur at ranges such that a partial impulse of 3.3 psi-msec (22.5 Pa-sec) or greater is delivered within 0.035 msec. Tactile perception could occur in the volume of water where the total shockwave energy flux density exceeds 0.06 in-lb/in^2 (1.1 milli-Joules/cm^2) and the peak shockwave pressure exceeds 17 psi (116 kPa), but the partial impulse is less than 3.3 psi-msec (22.5 Pa-sec). Neither tactile perception nor brief physical discomfort is likely to occur at ranges where the total shockwave energy flux density is less than 0.06 in-lb/in^2 (1.1 milli-Joules/cm^2), or when the peak shockwave pressure is 17 psi (116 kPa) or less.

The occurrence of brief physical discomfort is considered to be independent of mammal type, size, or weight. The maximum horizontal ranges for brief physical discomfort and tactile perception as well as the shockwave peak pressures at these ranges for the 10,000-lb (4536-kg) charge are presented in Table 9. Brief physical discomfort would be very likely to occur at ranges less than the maximum values shown in column 2 of Table 9. Tactile perception would be extremely unlikely at ranges that exceed the maximum range values shown in column 4 of Table 9. Tactile perception is likely to occur at ranges intermediate to the two maximum range values shown in Table 9.

Figure 17 presents range contours for brief physical discomfort and tactile perception for the 10,000-lb (4536-kg) charge.

Table 9. Maximum Ranges for Brief Physical Discomfort from and Tactile Perception of Underwater Explosion Shockwaves from a 10,000-lb (4536-kg) Charge.

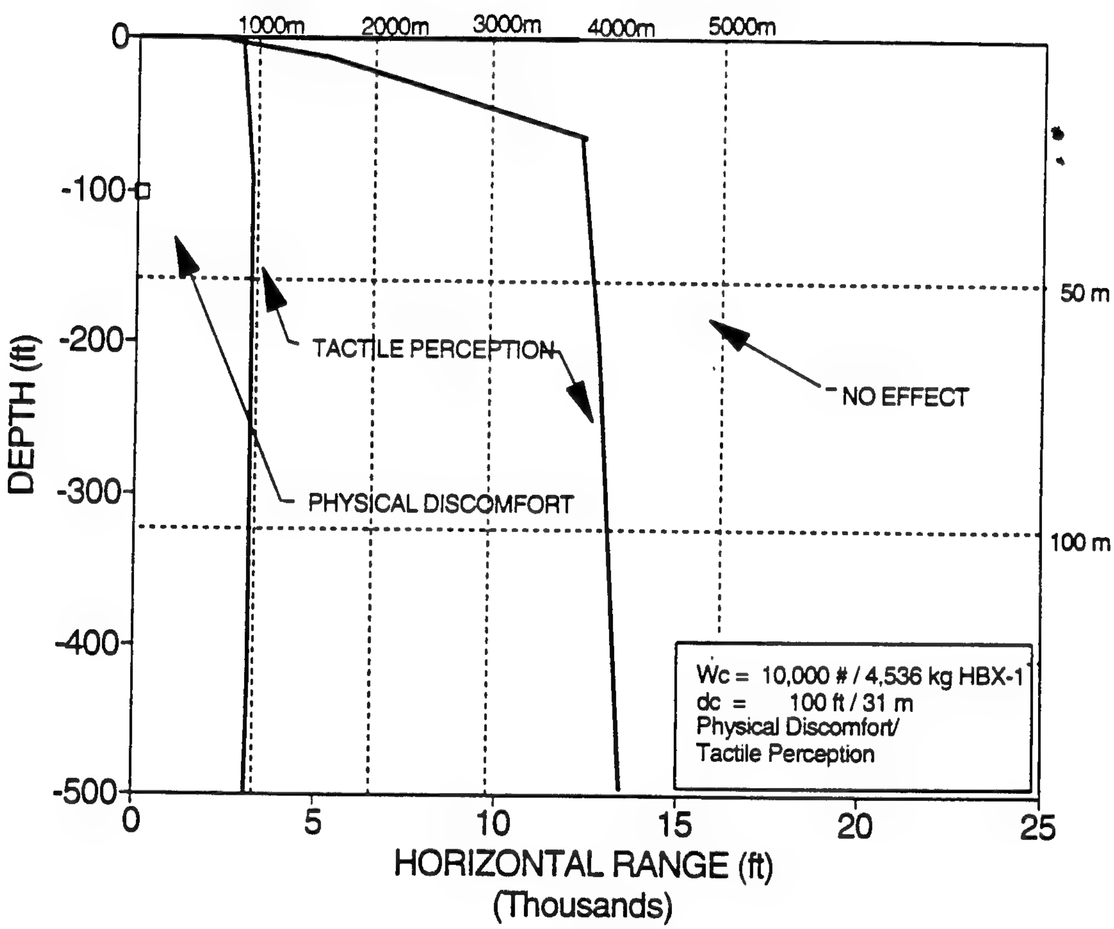
MAXIMUM RANGE FOR PROBABLE BRIEF PHYSICAL DISCOMFORT		MAXIMUM RANGE FOR PROBABLE TACTILE PERCEPTION	
Range ft/(m)	P_{max} psi/(kPa)	Range ft/(m)	P_{max} psi/(kPa)
3100 / (945)	83 / (566)	13,830 / (4215)	17 / (116)

Source: CD-NSWC/UERD, after Christian and Gaspin (1974)

The non-injurious physical discomfort which would only occur to animals which were undetected by active mitigation measures is of such brevity that any disruption of behavioral patterns would be expected to be temporary and not harmful to the animals.

E. Effects of Bulk Cavitation

"Cavitation occurs when compression waves, which are generated by the underwater detonation of an explosive charge, propagate to the surface and are reflected back into the water as rarefaction waves. These rarefaction waves cause a state of tension to occur within a large region of water. Since water cannot ordinarily sustain a significant amount of tension, it cavitates and the surrounding



Source: CD-NSWC/UERD

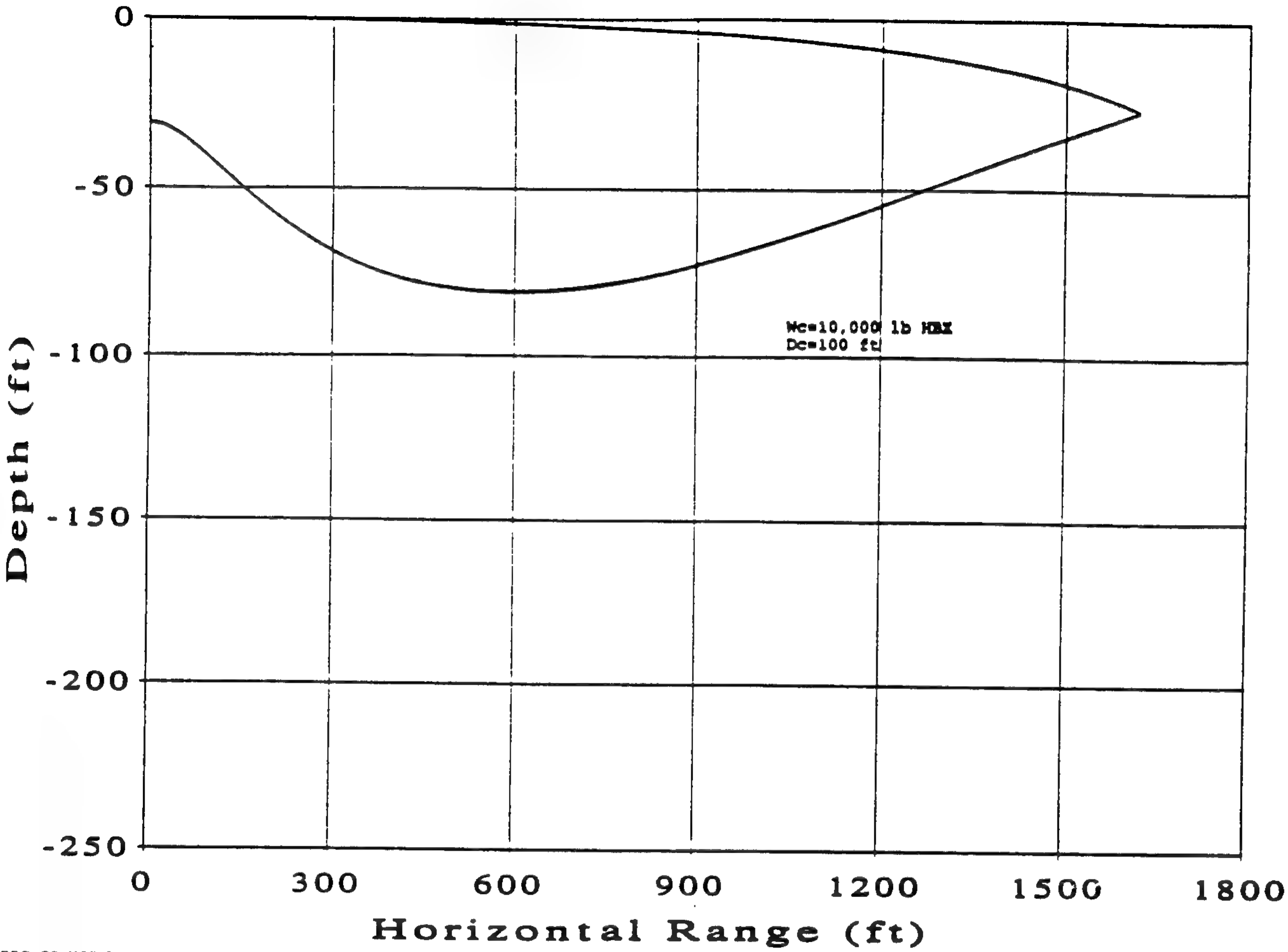
Figure 17. Contours for Brief Physical Discomfort and Tactile Perception from a 10,000-lb (4536-kg) Charge.

pressure rises to the vapor pressure of water. The region in which this occurs is known as the bulk cavitation region, and it includes all water which cavitates at any time after the detonation of the explosive charge. The upper and lower boundaries, which show the maximum extent of the cavitated region, form what is referred to as the bulk cavitation envelope. ...The time of bulk cavitation closure is defined as the time at which the lower boundary displacement equals the surface layer displacement. It is at this time that the accreting surface layer and the accreting lower boundary collide and generate the water hammer pressure pulse," (Costanzo and Gordon, 1989).

The direct effects of cavitation on marine mammals are unknown. Presence within the negative pressure cavitation zone could injure the auditory system or lungs. A mammal located at (or in the immediate vicinity of) the cavitation closure depth would be subjected to the water hammer pressure pulse. The magnitude of the closure impulse can range from insignificant (smaller charges) to substantial (larger charges); however, at the calculated ranges for onset of lung hemorrhage as well as both 1% and 50% mortalities, the closure impulse is less than the required shockwave impulse required to cause the stated degree of injury.

The presence of a marine mammal within the cavitation region created by the detonation of small charges could annoy, injure, or even increase the severity of the injuries caused by the shockwave. The area of cavitation from a 10,000-lb

(4536-kg) charge would be expected to be an area of near total physical trauma. It is not expected that any fish or smaller animals would survive the combined effects of the relatively high shockwave impulses and the violent cavitation. The maximum lateral extent of this cavitation area is 1620 ft (494 m) for the 10,000-lb (4536-kg) charge, utilizing the methods of Costanzo and Gordon (1989). (Refer to Figure 18 for delineation of the cavitation region.) Peak shockwave pressure at the above horizontal distance from the charge is 159 psi (1084 kPa).



Source: Costanzo and Gordon (1989)

Figure 18. Bulk Cavitation Region - 10,000-lb (4536-kg) Charge.

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Ridgway, S. H., and D. A. Carder; 1993. Features of dolphin skin with potential hydrodynamic importance. IEEE Engineering in Medicine and Biology: 83-88.

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APPENDIX E

CRITERION FOR MARINE MAMMAL ACOUSTIC DISCOMFORT

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APPENDIX E

This appendix describes a criterion for acoustic discomfort in marine mammals. The criterion is used to define an acoustic discomfort range for marine mammals which may occur near underwater detonations. This information is used in the Environmental Consequences section of the DEIS.

TABLE OF CONTENTS

INTRODUCTION

An underwater explosion produces pressure pulses that have the potential for damaging the hearing of sea mammals that are too close to the explosion. Criteria for use in determining hearing-safe ranges have been developed for sea mammals exposed to underwater detonation of 10,000-lb charges.

Investigators with expertise in underwater-explosion acoustics and experts in marine-mammal hearing have agreed that acoustic-safety criteria for mammals exposed to underwater noise should be based on the amount of acoustic energy that impinges on the mammal ear.

Hearing threshold, which varies with frequency, is the quietest sound that can be heard. Hearing safety limits lie considerably above the hearing threshold. The most conservative safety limit is the highest sound level that causes no temporary threshold shift (TTS). A danger limit is the lowest sound level that causes permanent threshold shift (PTS), which is hearing loss.

The most meaningful criterion for determining acoustic safe ranges for sea mammals would be one that is based on measurements of TTS resulting from exposure to underwater noise. For underwater detonations such criteria should be species-specific and based on TTS measured for mammals exposed to underwater explosions.

The following summarizes the rationale and assumptions on which the predictions for SEAWOLF are based.

METHODOLOGY

Hearing thresholds for odontocetes and pinnipeds exposed to pure tones (*i.e.*, sine waves) of at least one-second duration have been measured. An exhaustive search by Richardson *et al* has revealed no available hearing-safety data (TTS or PTS) for any sea mammals.[1] Therefore, other methods must be used to estimate the potential for acoustic damage.

There are data for human underwater tolerance limits (levels that are uncomfortable but cause no TTS). Some measurements were made on hooded divers exposed to underwater explosions.[2] Unfortunately, these data could not be used because we have no information on the amount of attenuation provided by the hoods.

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[1] Richardson, W. J, Greene, C. R., Malme, C. I. and Thomson, D. H., *Marine Mammals and Noise*, Academic Press, Inc., San Diego, CA, 1995.

[2] Wright, H. C., Davidson, W. M. and Silvester, H. G., *The Effects of Underwater Explosions on Shallow Water Divers Submerged in 100 Feet of Water*, Medical Research Council, Royal Naval Personnel Research Committee, RNP 50/639, UWB 21, RNPL 4/50, October 1950.

Data obtained from unhooded humans immersed in water and exposed to brief pure tones, were used, assisted by human in-air data, to construct an underwater hearing-safety limit for marine mammals. This limit was then applied to define a very conservative safe range for exposure to an underwater detonation of a 10,000-lb explosive charge.

HUMAN HEARING UNDER WATER

One study on humans measured threshold shift after 15 minutes' exposure, both in air and underwater, to a 3500 Hz pure tone.[3] Because these data are for long exposure to pure tones, they are not applicable to our problem.

Figure 1 shows underwater hearing thresholds for odontocetes and humans.[4,5] The solid human-data curve does not have the same slope as the odontocete data, but it lies very close at 1500 Hz, the frequency at which human tolerance level was also measured.

The plotted square is a hearing-tolerance level, found by exposing hoodless divers to one-second-duration 1500-Hz tones from a source directly in front of them.[5] The tones were gradually increased in level by 1 dB until the divers wanted to go no further. An in-air hearing test conducted within 5 minutes of the underwater test showed no hearing damage and no TTS. The plotted square is useful as a conservative (no TTS) limit for sea mammals, but a limit is needed at more than one frequency. To obtain this limit, data on human hearing in air were used.

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[3] Smith, P. F., Howard, R., Harris, M. and Waterman, D., *Underwater Hearing in Man: II. A Comparison of Temporary Threshold Shifts Induced by 3500 Hz Tones in Air and Underwater*, Report Number 608, U.S. Naval Submarine Medical Center, Groton, CT, 1970

[4] Richardson, W. J. *et al*, *Effects of Noise on Marine Mammals*, LGL Ecological Research Associates, Inc., Bryan, TX, done for Mineral Management Service, Herndon, VA, PB91-168914, Feb 91 [p. 180]

[5] Montague, W. E., and Strickland, J. F., *Sensitivity of the Water-Immersed Ear to High- and Low-Level Tones*, J. Acoust. Soc. Am. 33(10):1376-1381 (1961)

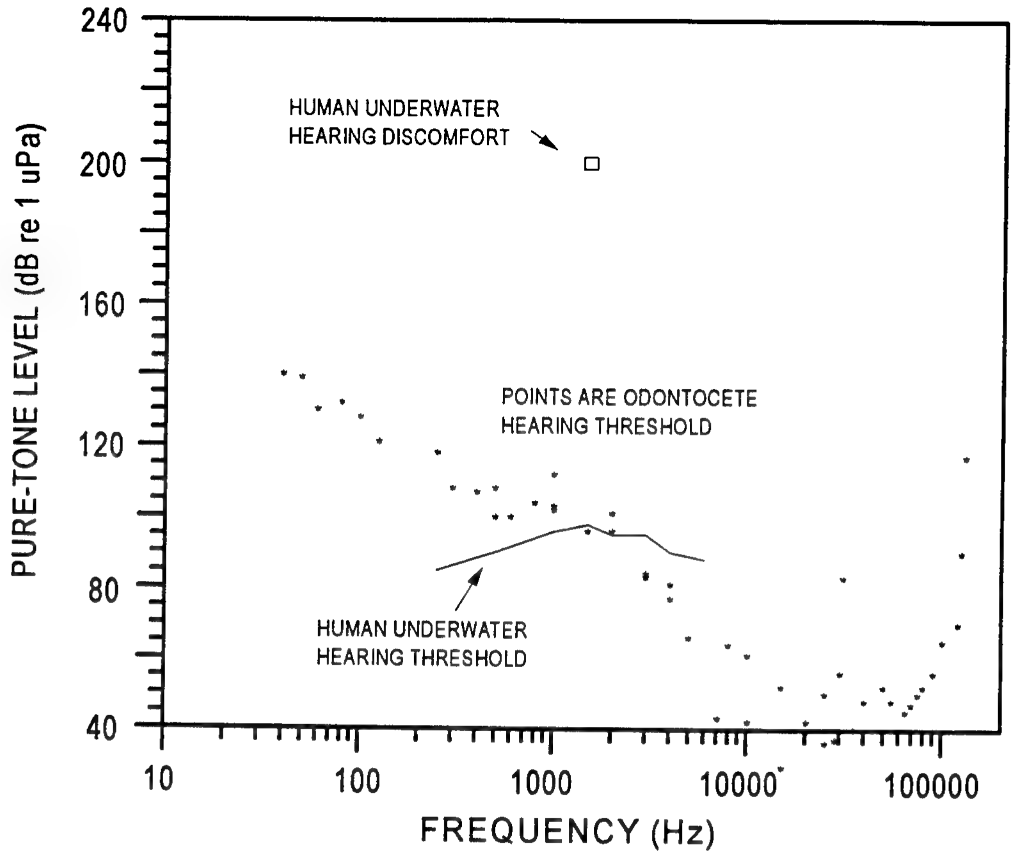

FIGURE 1. Odontocete and Human Underwater Hearing Thresholds

There are human data in air for threshold, discomfort and pain.[6,7] Figure 2 shows these levels. In Figure 3 the in-air data have been shifted by 100 dB, so that the human threshold matches the odontocete threshold in the 100 to 1000 Hz range. The discomfort and pain curves have been shifted by the same amount. The shifted "human pain" and "human discomfort" curves lie just above the measured-in-water human-tolerance data point (the square); this gave us confidence that use of the in-air data was not completely unreasonable. The dotted line was then drawn through the square and parallel to the upper in-air curves. This line can then be used as a safety limit for continuous tones.

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[6] Everest, F. A., *The Master Handbook of Acoustics*, 3rd ed. (Tab Books, McGraw-Hill, N. Y., 1994) [p. 43]

[7] Edge, P. M., Jr., and Mayes, W. H., *Description of Langley Low-Frequency Noise Facility and Study of Human Response to Noise Frequencies Below 50 cps*, NASA TN D-3204, 1966.

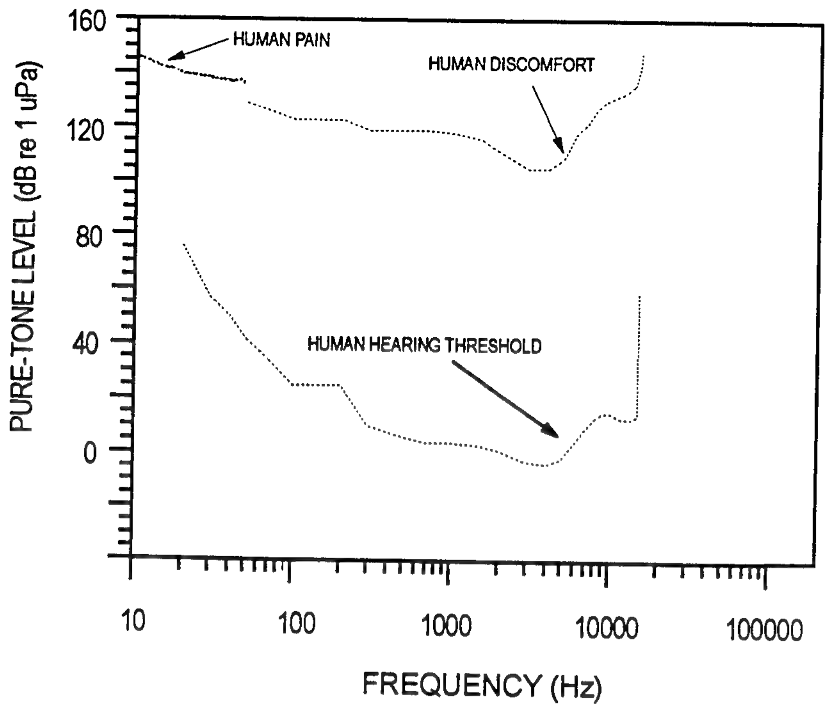

Figure 2. Human In-Air Hearing Threshold, Discomfort and Pain Levels

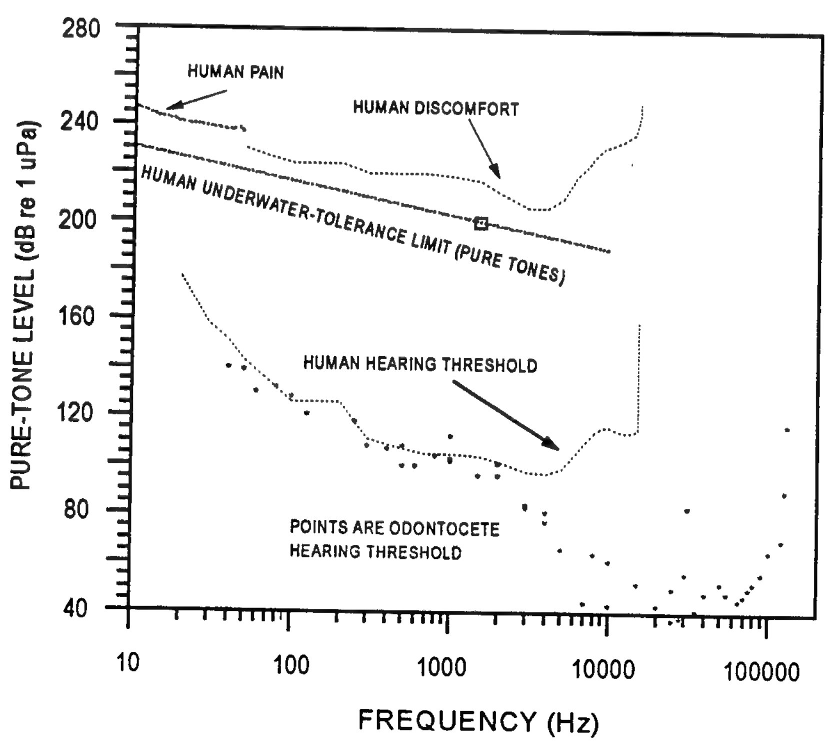

Figure 3. Human In-Air Limits Shifted to Match Odontocete Data: Setting Slope of Human Underwater Limit

Because human and dolphin hearing are comparable at their respective frequencies of best hearing, it was suggested that the method of shifting the human in-air data be modified. The dolphin frequency range reflects their specialized use of high-frequency sound. Therefore, to extrapolate from human to dolphin hearing mechanics, we have shifted the human auditory curve up in frequency by a factor of ten to match the range of the dolphin hearing curve. The level of the human curve (see Figure 2) has also been shifted up by 45 dB to match the odontocete threshold level. The discomfort and pain curves have been shifted by like amounts. Since we now can no longer make use of the single human underwater-tolerance data point (the square in Figure 3), we proposed the straight line that skims the bottom of the human-discomfort curve in Figure 4 as the revised safety limit for sea-mammal hearing.

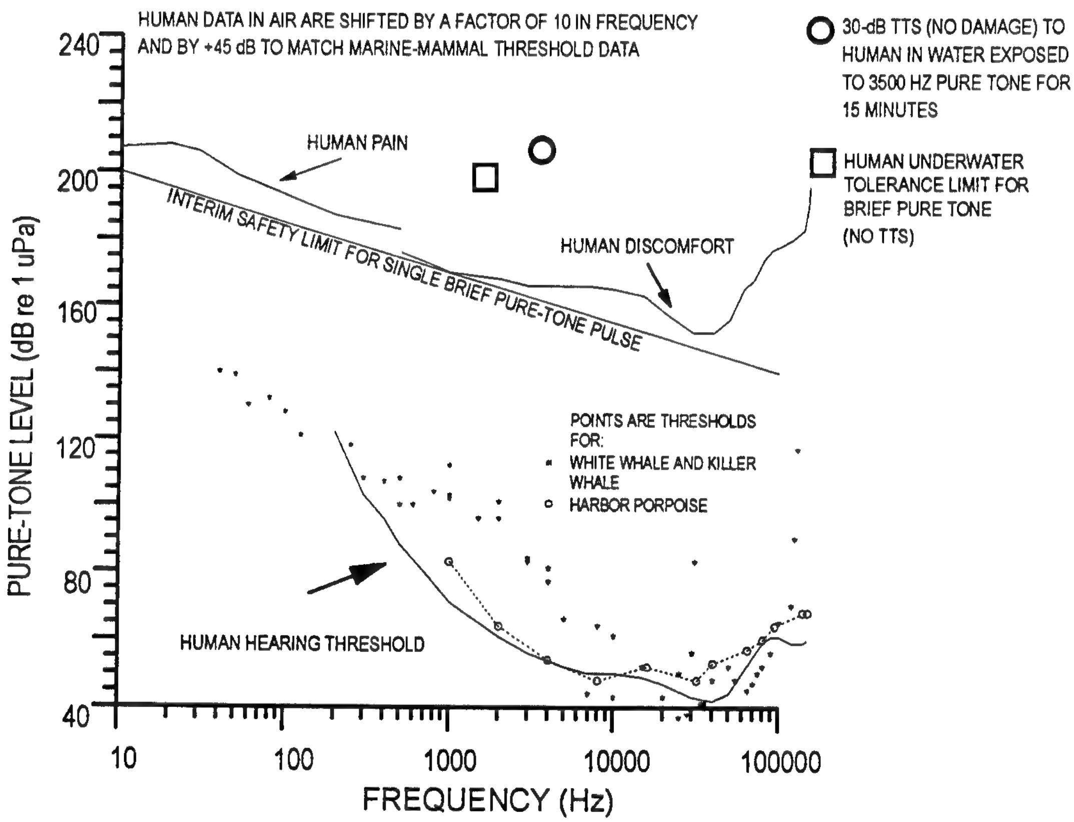

Figure 4. Interim Marine-Mammal Safety Limit for Pure Brief Tones: Based on Shifted, Human In-Air Data

The line in Figure 4 is 30 dB lower than the very conservative human underwater-tolerance limit presented in Figure 3. An additional indication of how conservative this line is for humans is the circle plotted in Figure 4. Humans were exposed to a 3500-Hz pure tone for 15 minutes. Two minutes after exposure, a TTS of 30 dB (no damage) was measured.[8]

[8] Smith, P.F., Howard, R., Harris, M. and Waterman, D., Underwater Hearing in Man: II. A Comparison of Temporary Threshold Shifts Induced by 3500 Hertz Tones in Air and Underwater, Submarine Medical Research Laboratory, U.S. Naval Base, Groton, Conn., 15 Jan 1970

In order to convert the above limit to energy, so that it can be compared with explosion output, we made use of the integration time of the ear. For humans, the integration time is about 0.1 to 0.2 seconds. Because we could find no clear value for the integration time of marine mammals, we have used 0.1 seconds, which appears conservative for porpoises [9], to define an underwater hearing-safety limit for humans, which was originally proposed as a "sea-mammal hearing-safety limit".

Figure 5 shows how the criterion can be applied to the calculated energy field. The new "interim safety limit" (Figure 4), has been converted to energy and is plotted as a dotted line. Considering the basis for its derivation, we believe this should be viewed as a criterion for acoustic discomfort or annoyance.

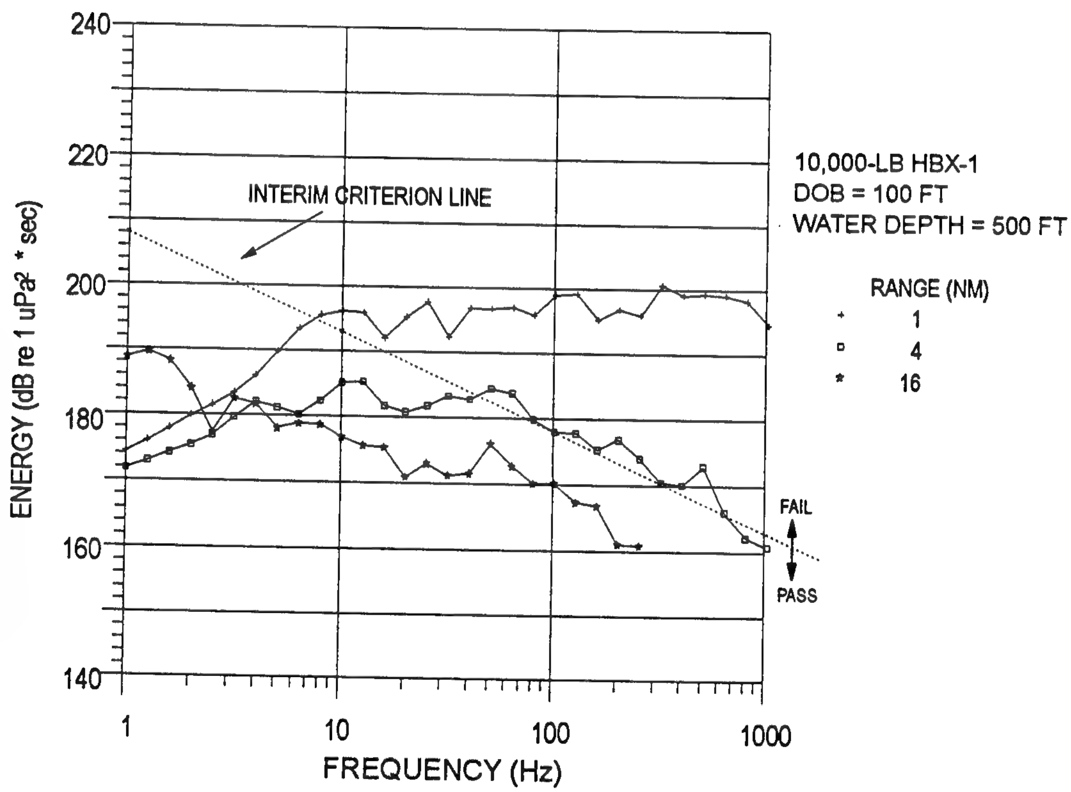

Figure 5. Example of Application of Interim Hearing-Safety Limit

[9] Johnson, C. S., *Relation between Absolute Threshold and Duration-of-tone Pulses in the Bottlenosed Porpoise*, J. Acoust. Soc. Am. 43 (4) 757-763, 1968.

Although audiograms have been measured for some odontocetes, the only information available for baleen whales is based on observation and anecdotal information.[10,11] Figure 6 shows representative hearing ranges for ondontocetes and baleen whales.[12] Since these whales regularly and repeatedly produce source levels of 180 to 185 dB in the lower frequencies of this range without deafening themselves, the criterion we have employed should be conservative for them also.

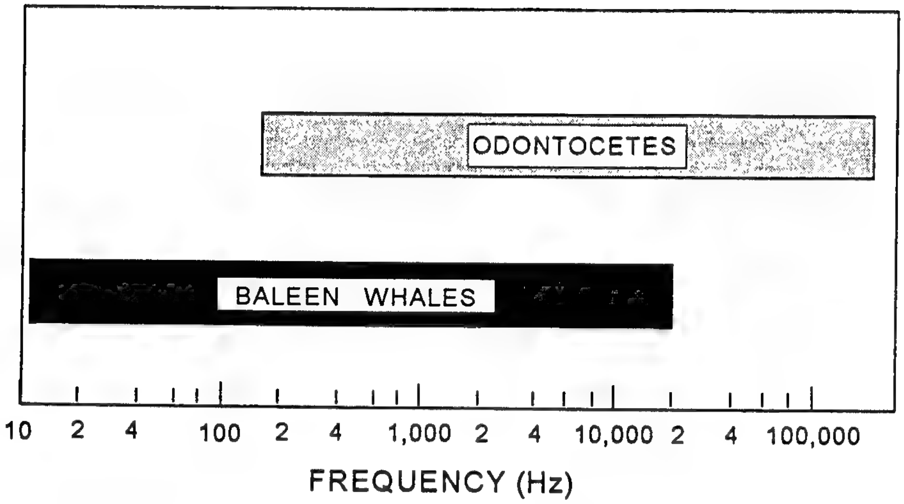

Figure 6. Representative Hearing Ranges for Large Whales and Dolphins

METHOD OF CALCULATION

The pulse train from a relatively shallow underwater explosion consists of a direct shock wave closely followed by companion surface-reflected and bottom-reflected pulses of opposite sign. For a 10,000 lb charge, a 100- or 200-ft charge depth is "relatively shallow".

The procedure for dealing with explosion pulses is to:

1) calculate the pressure-vs-time (p-t) waveform;
2) obtain the spectrum as energy/Hz;
3) integrate the spectrum to get energy/(1/3-octave band);
4) compare this energy directly with the safety limit.

[10] Ketten, D. R., *The Marine Mammal Ear: Specializations for Aquatic Audition and Echolocation*. p 717-750 in The Biology of Hearing, Springer-Verlag, Berlin, 1991.

[11] Ketten, D., *The Cetacean Ear: Form, Frequency, and Evolution*. p 53-75 in Marine Mammal Sensory Systems, Plenum, New York, 1992.

[12] Ketten, D. *et al*, Marine Mammal Bio-Acoustics Short Course, Orlando, FL, 1995.

The p-t waveform is calculated with the REFMS computer code[13], Version 5.0. A water sound-speed profile and a bottom profile are required. A charge size and depth are chosen. Then, for a given range, waveforms are calculated at the desired depths (in this case, selected mammal locations). Energy spectra are obtained from the p-t waveforms by standard methods.

For the SEAWOLF calculations, we employed sound-speed profiles measured in the two proposed test areas. To be conservative, we have used the complete calculated pulse train even if it contains pulses separated by more than 0.1 seconds. (It could be argued that pulses separated by more than 0.1 seconds allow the ear to recover, and so the pulses should be considered individually.)

DISCUSSION OF RESULTS

Using the limited number of archival sound-speed profiles available for the two proposed test sites, calculations were made of the acoustic environment to which sea mammals might be exposed as a result of detonating 10,000-lb charges for the SEAWOLF shock test. The mammal depth was varied from 50 feet to 400 feet (in 500 feet of water). Plots of energy (in 1/3-octave bands) were made for ranges from one nautical mile (nm) to as much as 6 or 8 nm. The interim criterion line has been plotted along with the energy level as a function of mammal depth at the indicated range.

Figures E-1 through E-6 show selected plots for the Norfolk test area; Figures E-7 to E-11 are results for the Mayport area. Although the water column in the Mayport area seems to have a rather stable velocity structure, there are very few archival profiles available. Profiles in the Norfolk area are quite variable. In the latter region, vortices from the Gulf Stream can cause wild swings in both sound-speed and current profiles in as little as 24 hours. Since the Mayport test area is also adjacent to the Gulf Stream, one might expect variability similar to that observed near Norfolk.

Although we do not have energy plots at 6 and 8 nm for all the cases shown in Appendix E, we can generalize to some extent about the calculations made using the archival profiles from these two areas. For the same profile, the 1/3-octave-band energy levels tend to drop by 5 to 10 dB going from 1 to 2 nm, another 5-10 dB going from 2-4 nm, another 5 dB from 4-6 nm, and probably another 5 dB going from 6-8 nm. In addition, the drop-off with range becomes faster as the frequency increases.

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[13] Britt, J. R., Eubanks, R. J., and Lumsden, M. G., *Underwater Shock Wave Reflection and Refraction in Deep and Shallow Water: Volume I - A User's Manual for the REFMS Code (Version 4.0)*; Science Applications International Corporation, P.O. Box 469, St. Joseph, LA 71366-0469, DNA-TR-91-15-V1, June 1991.

For both areas, archival profiles can give us only an indication of the variability one might expect during a given time period. The cases shown are for profiles most representative of the variability to be expected from April to July in the two areas

Generally, the interim safety limit, which we consider to be extremely conservative insofar as acoustic damage to the mammal ear, indicates a probable range for discomfort or annoyance from 4 to 6 nm. The trend is for the "safe" range to become shorter later in the summer and into early fall. This is a function of the increasing temperature of the water.

There is a variation with mammal depth, however. In general, the deeper the mammal, the lower the explosion-noise level at range. In some cases, the calculated "safe" range for a mammal at 100 feet is greater than 6 nm, even though all other depths indicate a range within 4 to 6 miles. When we make calculations for a depth of 50 feet, however, the curve tends to drop below the 100-foot curve. (See Figures E-6 and E-11.)

While most of the calculations were performed for frequencies up to 1 kHz, a few have been extended to 10 kHz and beyond. (See Figures E-4 to E-6 and Figures E-9 to E-11.) Because acoustic attenuation at 10 kHz is extremely high and increasing rapidly, the explosion energy falls off much more rapidly above this frequency. This is of most interest for the odontocetes at ranges of 6 nm and beyond, because their frequencies of best hearing tend to be in the 30 to 40 kHz region.

Although the April profiles show portions of some of the curves above the criterion at 6 nm, these tend to be in the frequency range below 100 Hz, which is probably below the frequency of best hearing for the baleen whales. The parts of these curves that lie above the criterion between 100 and 1000 Hz (probably the range of best hearing for the baleen whales) are at or below the levels at which these animals regularly and repeatedly produce vocalizations that do not deafen them.

CONCLUSIONS

There are no existing data applicable to the definition of a meaningful criterion for potential auditory injury to marine mammals exposed to underwater explosions. The interim acoustic-energy limit developed for use in predicting the acoustic impact of the SEAWOLF detonations is based on human in-air data. Evidence that indicates how conservative this limit is for people has been provided by studies made with humans exposed to brief pure tones underwater (no TTS) and humans exposed to pure tones for 15 minutes underwater (30 dB TTS: no damage).

RECOMMENDATIONS

Until reliable measurements have been made of temporary threshold shift, TTS, that is directly attributable to exposure of marine mammals to underwater explosions, this interim criterion should be used only for defining ranges for "acoustic discomfort" or annoyance.

One must keep in mind that the actual acoustic field on any given day will depend on the sound-velocity structure at that time and on the actual bottom sediment and structure in the area. Calculations made using archival information provide only an estimate of what one should expect. Actual *in situ* profile measurements and calculations made on site during the test series must be used to guide those who will be responsible for monitoring and mitigation.

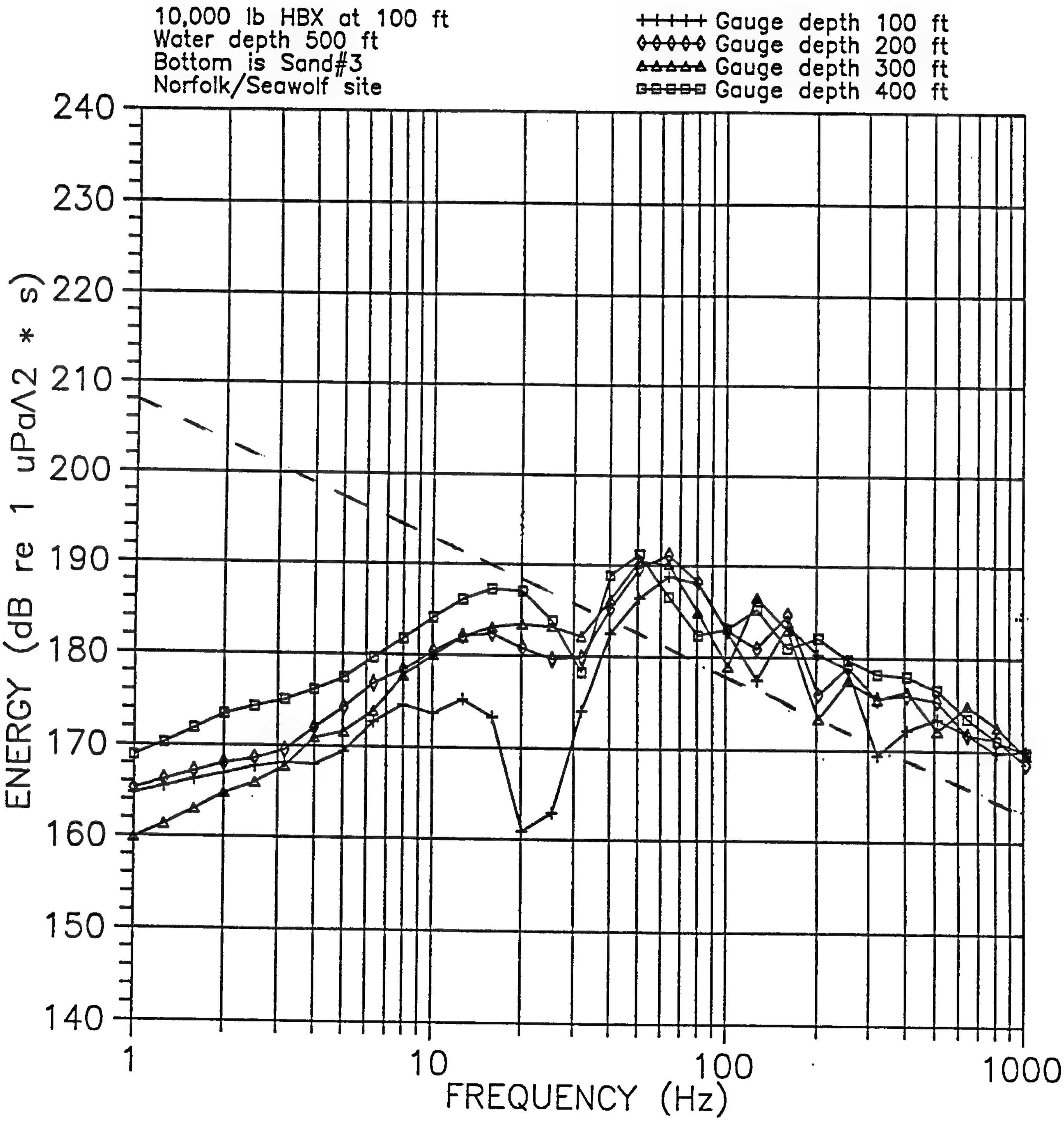

FIGURE E-1. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - NORFOLK AREA: APRIL; RANGE = 4 NM; MAMMAL DEPTH = 100 TO 400 FT

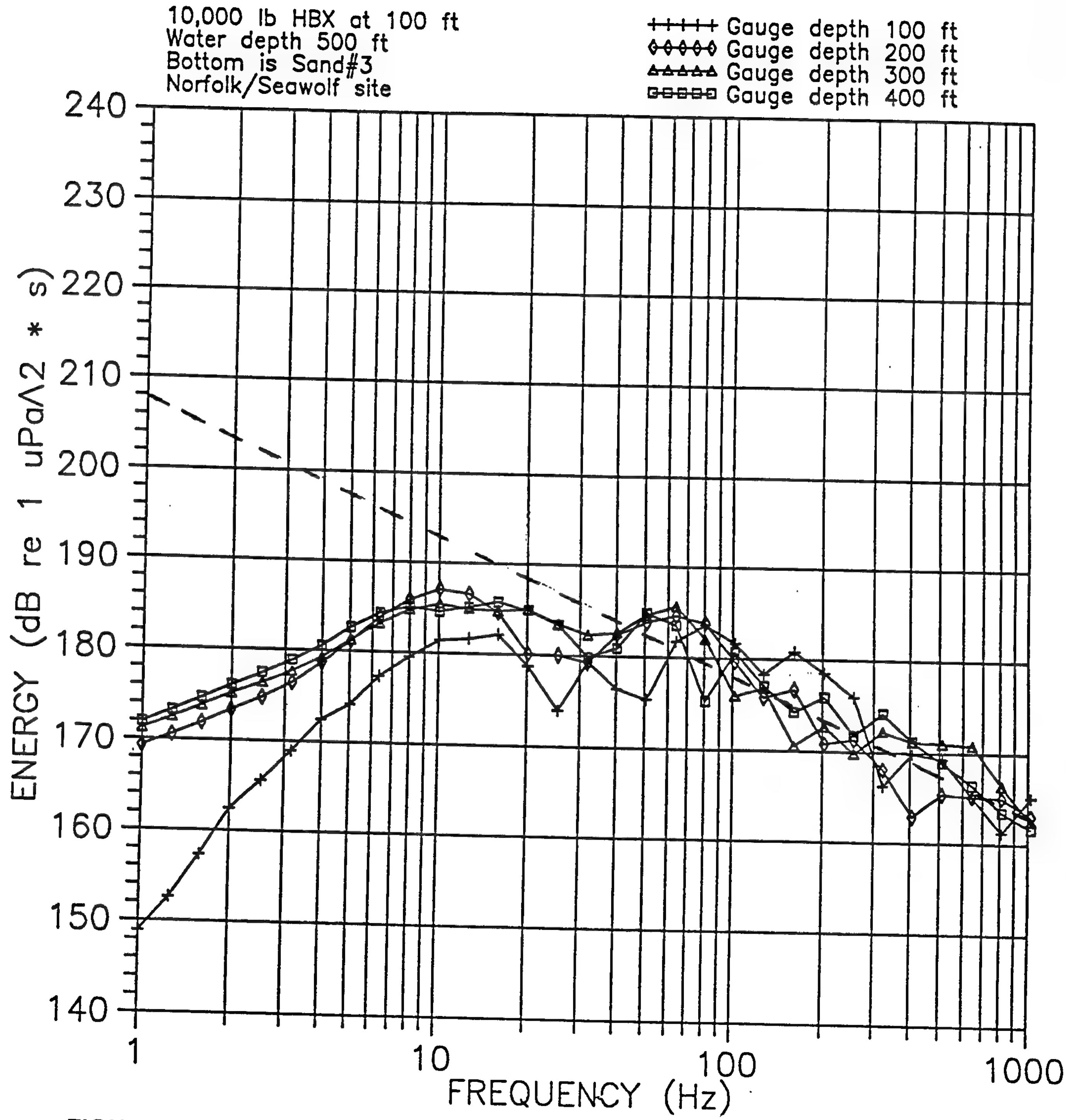

FIGURE E-2. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - NORFOLK AREA
APRIL; RANGE = 6 NM; MAMMAL DEPTH = 100 TO 400 FT

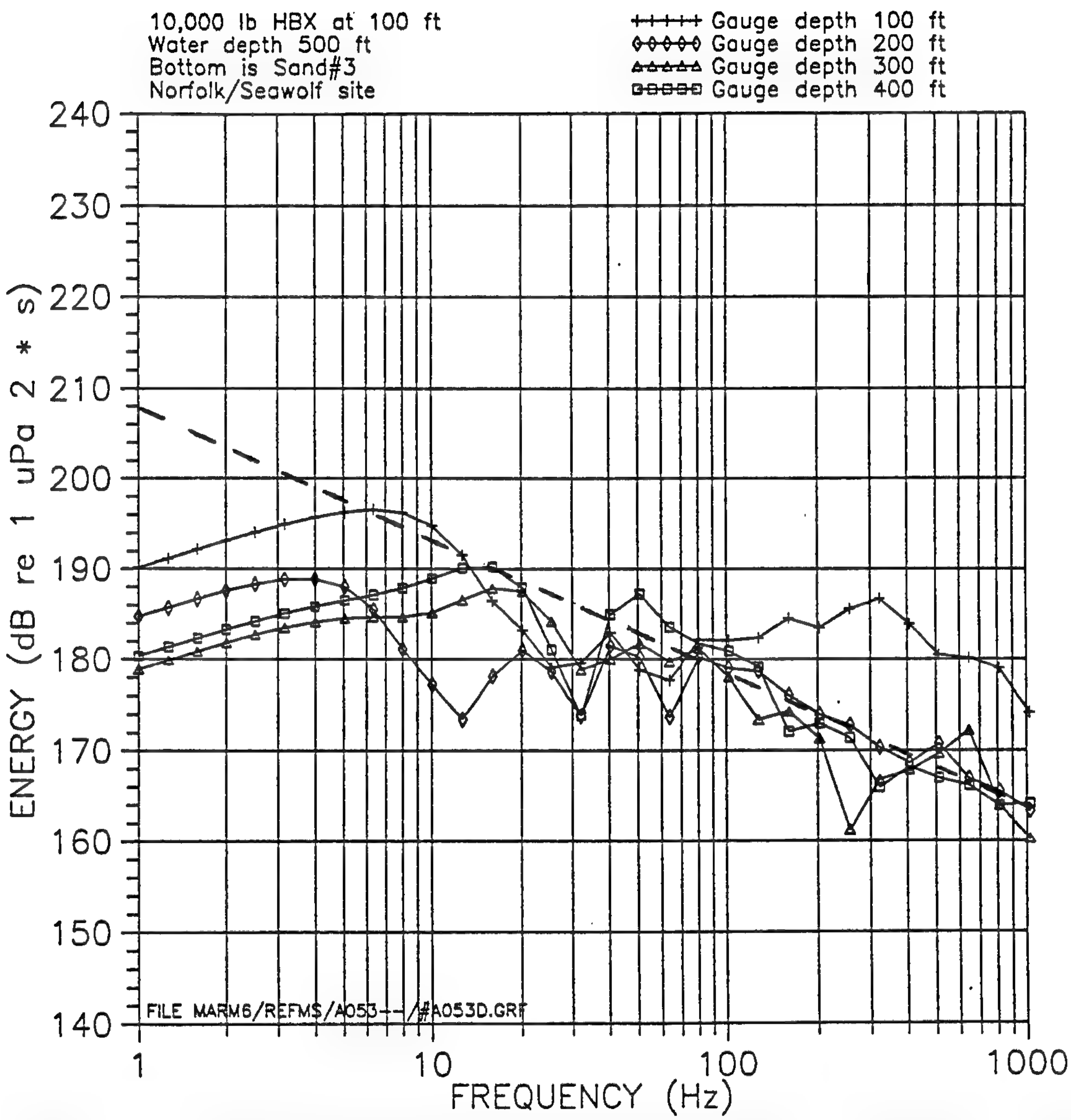

FIGURE E-3. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - NORFOLK AREA
MAY-EARLY JUNE; RANGE = 4 NM; MAMMAL DEPTH = 100 TO 400 FT

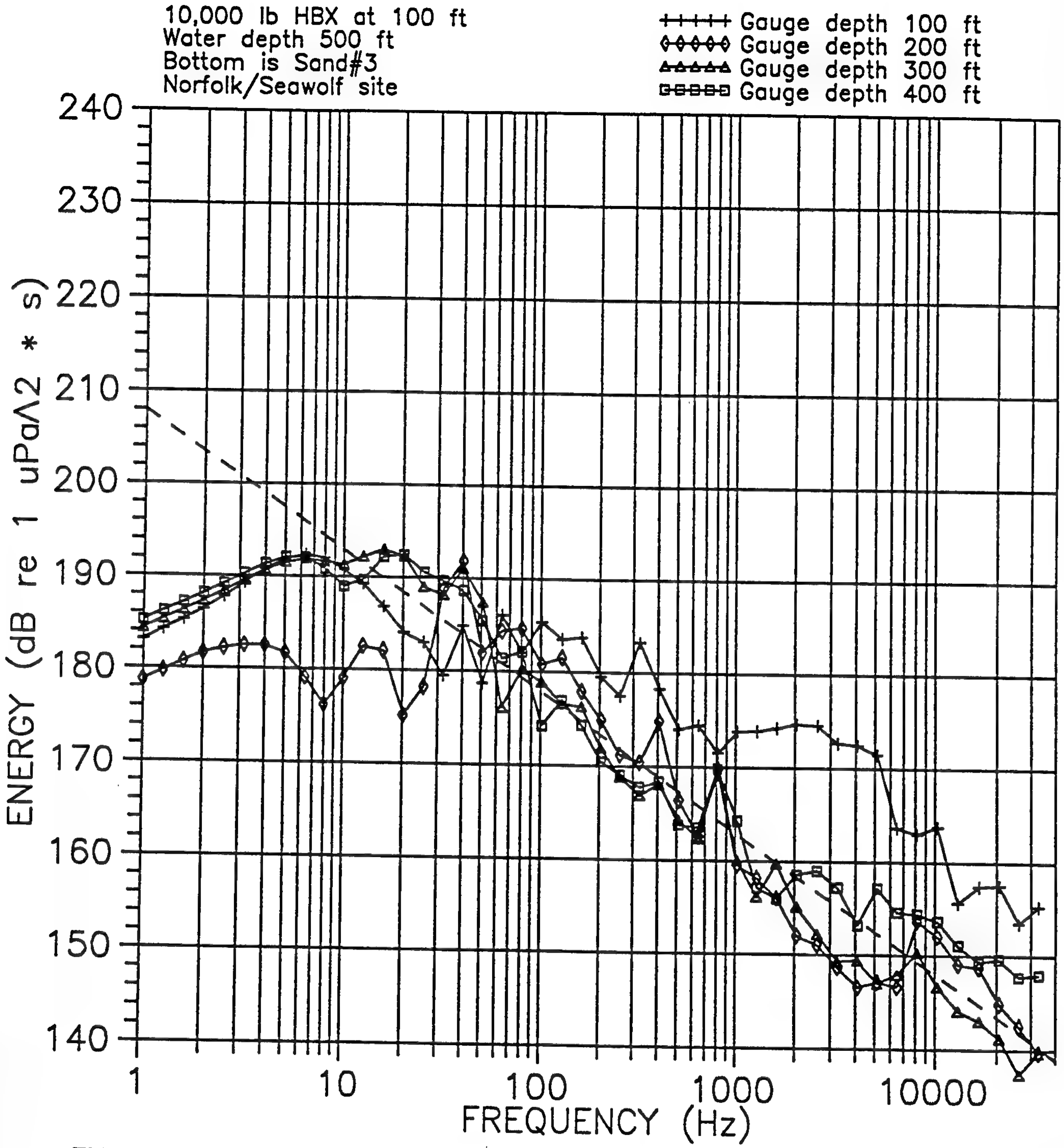

FIGURE E-4. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - NORFOLK AREA
LATE JUNE-EARLY JULY; RANGE = 4 NM; MAMMAL DEPTH = 100 TO 400 FT

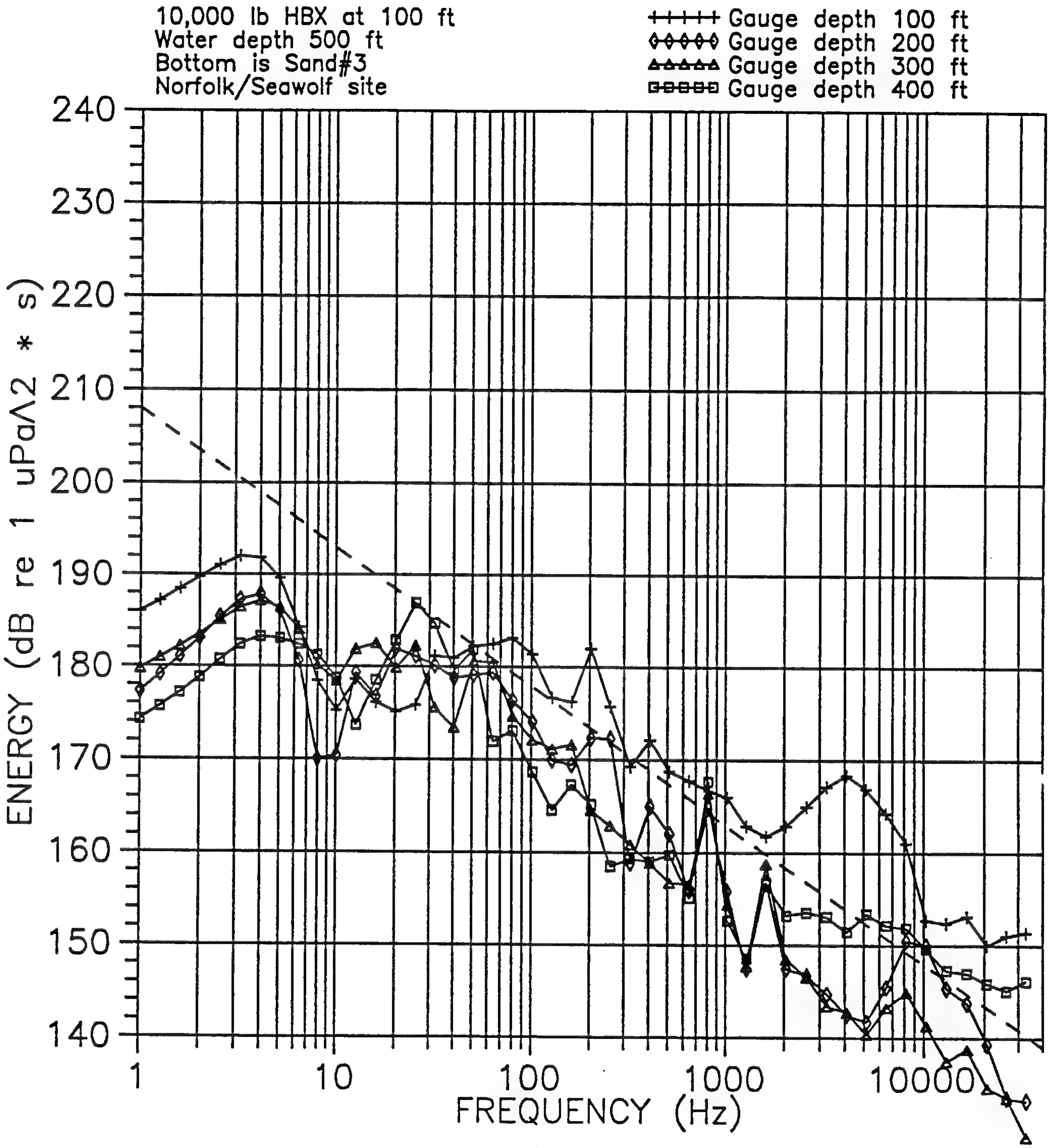

FIGURE E-5. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - NORFOLK AREA
LATE JUNE-EARLY JUNE; RANGE = 6 NM; MAMMAL DEPTH = 100 TO 400 FT

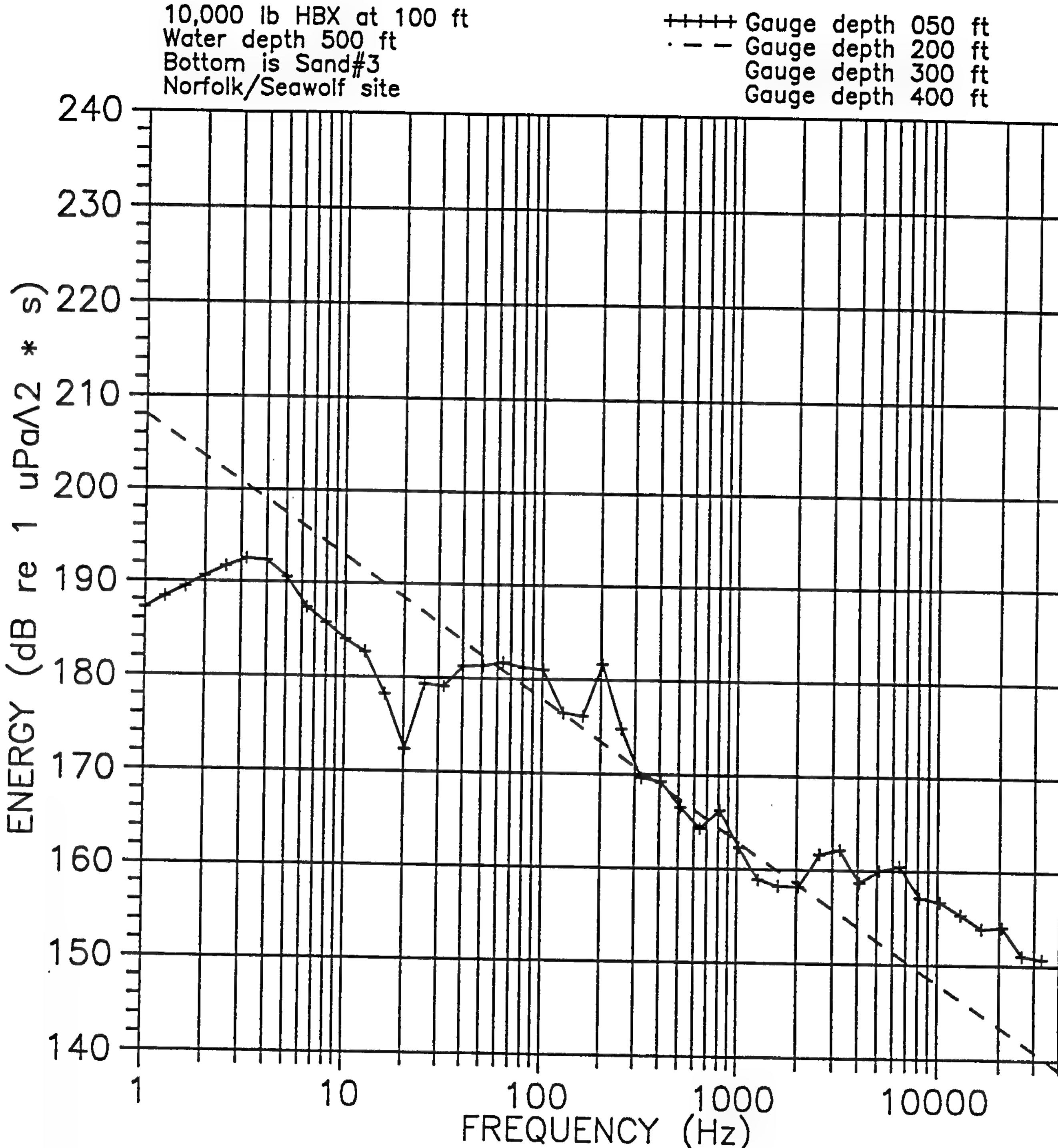

FIGURE E-6. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - NORFOLK AREA
LATE JUNE-EARLY JULY; RANGE = 6 NM; MAMMAL DEPTH = 50 FT

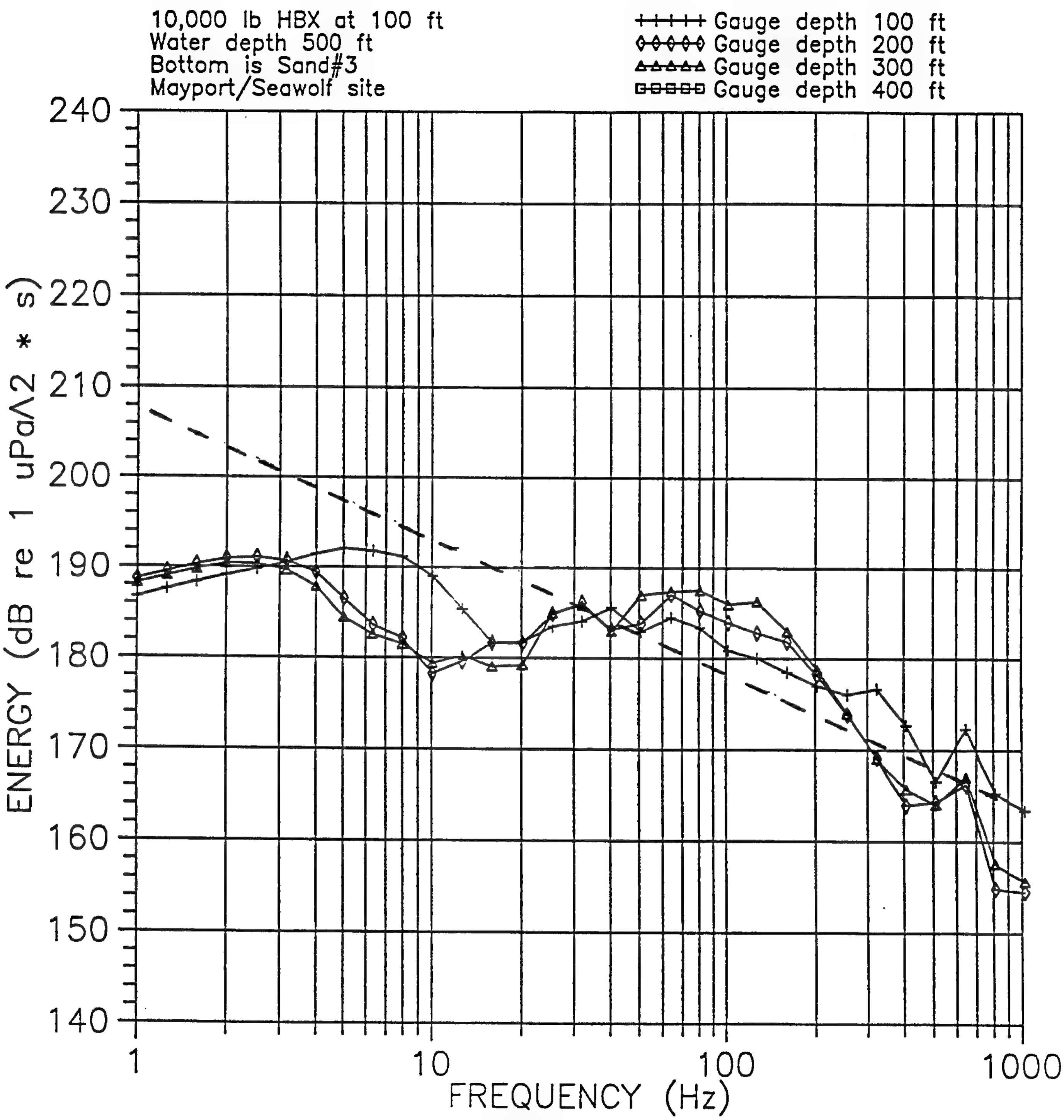

FIGURE E-7. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - MAYPORT AREA
APRIL-MAY; RANGE = 4 NM; MAMMAL DEPTH = 100 TO 400 FT

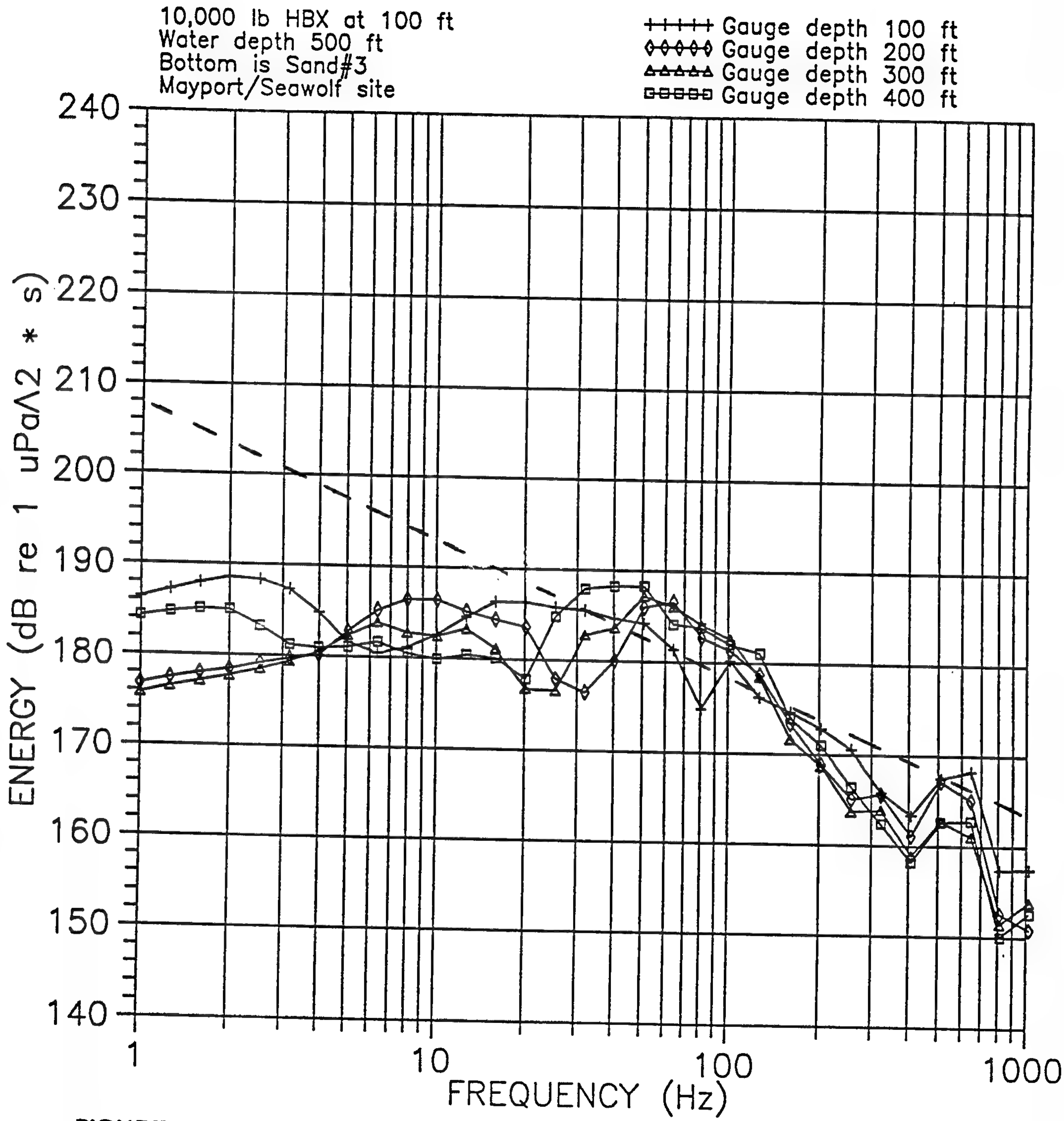

FIGURE E-8. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - MAYPORT AREA
APRIL-MAY; RANGE = 6 NM; MAMMAL DEPTH =: 100 TO 400 FT

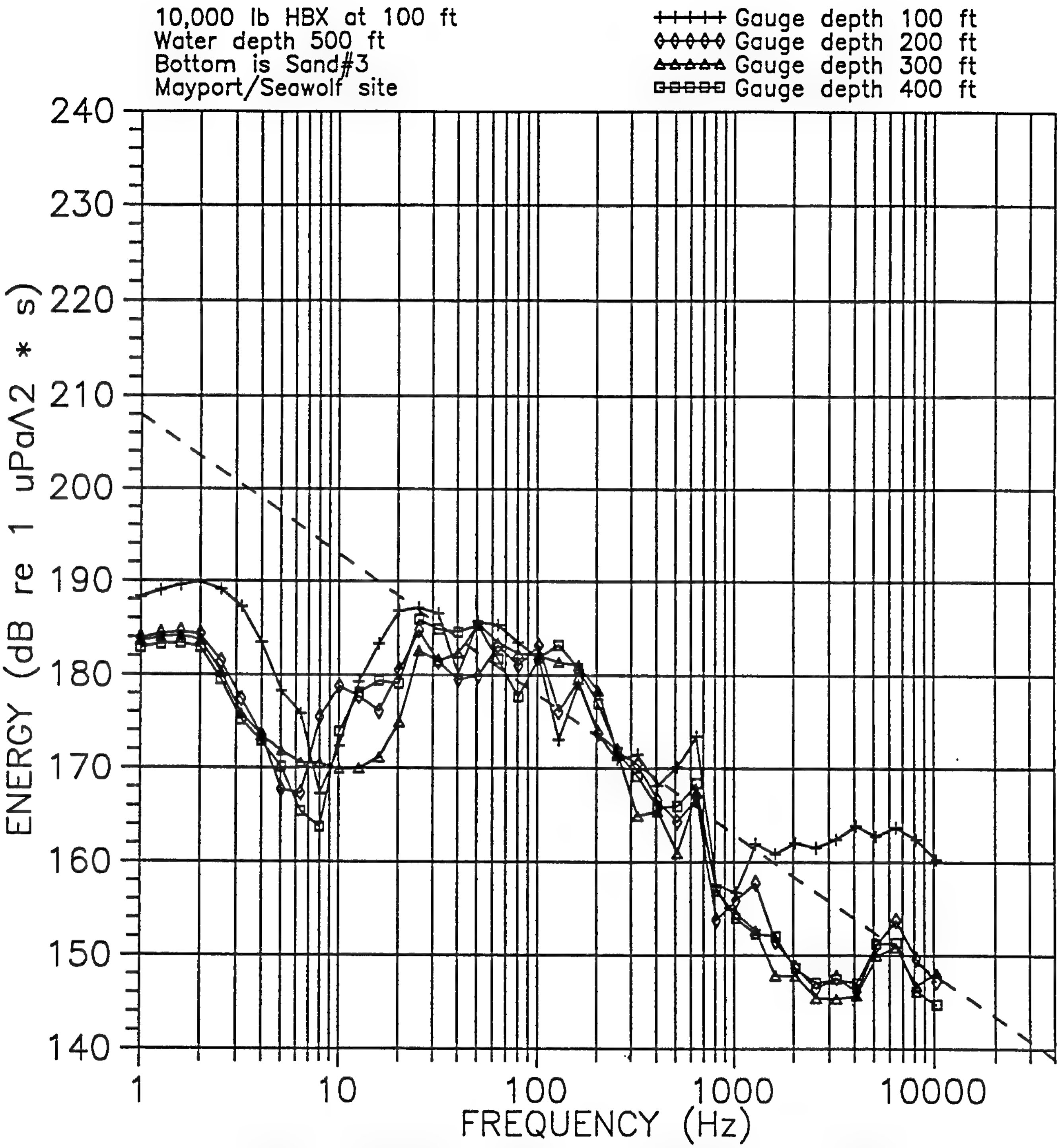

FIGURE E-9. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - MAYPORT AREA
JUNE-JULY; RANGE = 4 NM; MAMMAL DEPTH = 100 TO 400 FT

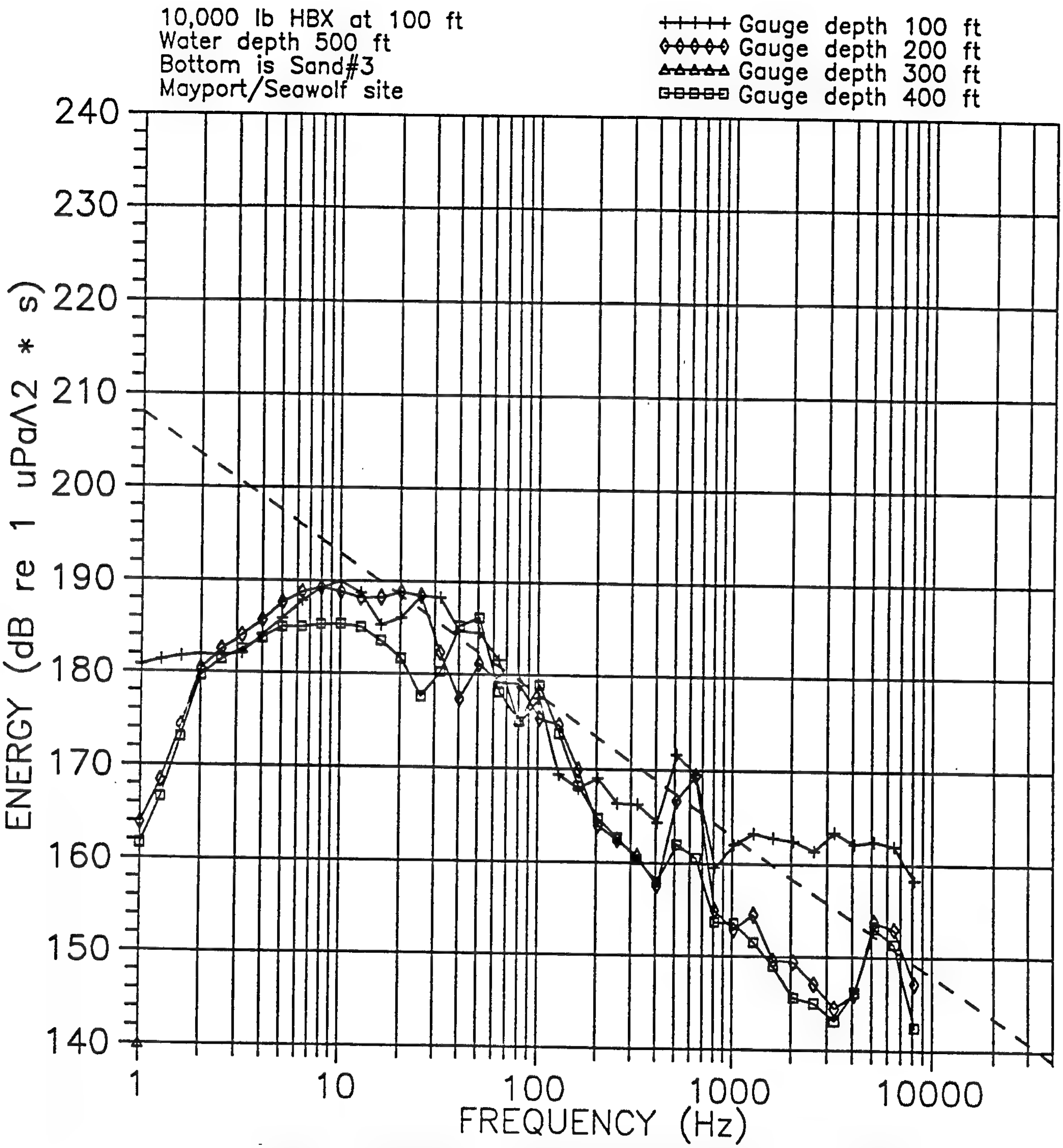

FIGURE E-10. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - MAYPORT AREA
JUNE-JULY; RANGE = 6 NM; MAMMAL DEPTH = 100 TO 400 FT

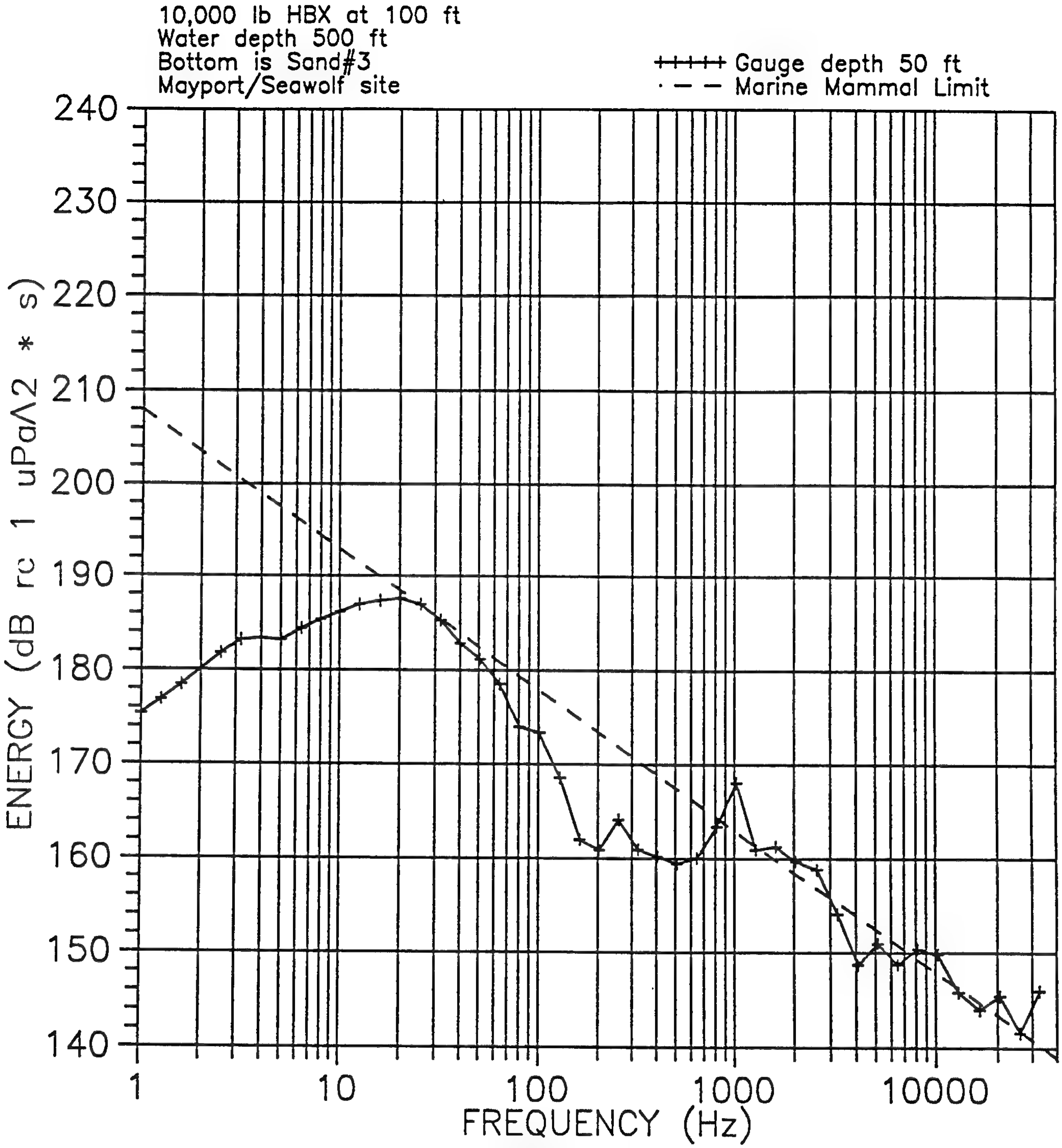

FIGURE E-11. 1/3-OCTAVE-BAND ENERGY VS FREQUENCY - MAYPORT AREA
JUNE-JULY; RANGE = 6 NM; MAMMAL DEPTH = 50 FT

APPENDIX F

NUCLEAR SAFETY

NUCLEAR SAFETY

This section evaluates the radiological environmental effects from shock testing SEAWOLF class submarines and provides relevant information on the Naval Nuclear Propulsion Program which, pursuant to federal law, regulates nuclear safety and radioactivity associated with nuclear propulsion work.

This section has been developed making full use of the extensive body of unclassified environmental and technical information available on nuclear propulsion matters. This information includes detailed annual reports published over three decades; independent environmental surveys performed by the Environmental Protection Agency, by states in which Naval Nuclear Propulsion facilities are located and by some foreign countries; and a thorough independent review performed by the Government Accounting Office in 1991.

1 Introduction

1.1 History and Mission of the Program

In 1946, at the conclusion of World War II, Congress passed the Atomic Energy Act, which established the Atomic Energy Commission (AEC) to succeed the wartime Manhattan Project, and gave it sole responsibility for developing atomic energy. At that time, then-Captain (later Admiral) Hyman G. Rickover was assigned to the Navy Bureau of Ships, the organization responsible for Naval ship design. Rickover recognized the military implications of successfully harnessing atomic power for submarine propulsion, and that it would be necessary for the Navy to work with the AEC to develop such a program. By 1949, Rickover had forged an arrangement between the AEC and the Navy that led to the formation of the Naval Nuclear Propulsion Program. In 1954, the nuclear submarine USS NAUTILUS put to sea and demonstrated the basis for all subsequent U.S. nuclear-powered warship designs. In the 1970's, government restructuring moved the Naval Nuclear Propulsion Program from the AEC (which was disestablished) to what became the Department of Energy. As the Naval Nuclear Propulsion Program grew in size and scope over the years, it retained its dual responsibilities within the Department of Energy and the Department of the Navy, and its basic organization, responsibilities, and technical discipline have remained as it was when first established.

Today, the Naval Nuclear Propulsion Program continues as a joint Navy/Department of Energy (DOE) organization responsible for all matters pertaining to Naval nuclear propulsion pursuant to Presidential Executive Order 12344, permanently enacted as Public Law 98-525 (42 USC 7158). The Program is responsible for:

1. The nuclear propulsion plants aboard 107 ships (including 1 research vessel) powered by Naval nuclear

reactors.

2. Two Moored Training Ships located in Charleston, South Carolina used for Naval nuclear propulsion plant operator training.

3. Nuclear work performed at eight shipyards (six public, including two currently being closed, and two private).

4. Two DOE government-owned, contractor-operated laboratories devoted solely to Naval nuclear propulsion research, development, and design work.

5. Land-based prototype Naval nuclear reactors used for research and development work and training of Naval nuclear propulsion plant operators.

The Naval Nuclear Propulsion Program's conservative design practices and stringent operating procedures have resulted in the demonstrated safety record of Naval nuclear propulsion plants. U.S. Naval reactors have accumulated over 4,600 reactor years of operation and have steamed over 100 million miles without a reactor accident or any significant radiological effect on the environment.

The following sections provide a brief discussion of the Naval Nuclear Propulsion Program. For further information on this subject see references 1, 2 and/or 3.

1.2 Nuclear Propulsion for Navy Submarines

Before the advent of nuclear power, the submarine was, in reality, a small surface ship that could submerge for only short periods of time. As it required oxygen as well as fossil fuel to operate its diesel engines, the submarine had to draw in air and exhaust combustion products. This required the submarine either to be on the surface, or close enough to the surface to use a snorkel, which made the ship susceptible to detection. To avoid detection, the ship had to submerge fully and rely on electric batteries which depleted within several hours. The ship would then have to surface again to start the diesel and recharge the batteries. By eliminating altogether the need for oxygen for propulsion, nuclear power offered a way to drive a submerged submarine at high speeds without concern for fuel consumption; to operate fully capable sensors and weapons systems during extended deployments; and to support a safe and comfortable living environment for the crew. Only a nuclear-powered submarine can operate anywhere in the world's oceans, including under the polar ice, undetected and at maximum capability for extended periods.

The U.S. Navy's nuclear powered ships have an unparalleled record of safety and reliability. Today, Naval nuclear powered ships

operate in and out of major U.S. ports and have visited over 150 foreign ports in over 50 countries and territories.

1.3 Philosophy of the Program

Since radioactive material is an inherent by-product of the nuclear fission process, its control has been a central concern for the Naval Nuclear Propulsion Program from the Program's inception. Radiation levels and releases of radioactivity have historically been controlled well below those permitted by national and international standards. All features of design, construction, operation, maintenance, and personnel selection, training and qualification have been oriented toward minimizing environmental effects and ensuring the health and safety of workers, ships crew members, and the general public. Conservative reactor safety design has, from the beginning, been a hallmark of the Naval Nuclear Propulsion Program. The stringent radiological control practices used in the Naval Nuclear Propulsion Program are documented in reference 4.

1.4 Safe Operational Record of the Program

The history of safe operation of the Navy's nuclear powered ships and their support facilities is a matter of public record. This record shows a long and extensive history of the Program's activities having no significant effect on the environment. Detailed environmental monitoring results published yearly provide a comprehensive description of environmental performance for all Naval Nuclear Propulsion Program facilities. Report NT-95-1 (reference 5) is the latest report for all the ships, bases, and shipyards. This record confirms that the procedures used by the Naval Nuclear Propulsion Program to control radioactivity from U.S. Naval nuclear powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public and has been independently corroborated by the Environmental Protection Agency.

The Naval Nuclear Propulsion Program has obtained independent evaluations from the Nuclear Regulatory Commission (NRC) and the Advisory Committee on Reactor Safeguards (ACRS) on naval reactor designs. These reviews were conducted as a means to provide independent confirmation and added assurance that nuclear propulsion plant design, operations and maintenance pose no significant risk to public health and safety.

In addition, the General Accounting Office (GAO), a Congressional investigative organization, in 1991 completed a thorough fourteen month review of DOE sites under the cognizance of the Naval Nuclear Propulsion Program (reference 6). This review included full access to classified documents. The GAO investigators also made visits to the DOE laboratory and naval reactor prototype sites supporting the Naval Nuclear Propulsion Program, which

operate to the same stringent standards imposed on Navy facilities and activities. The GAO review concentrated on environmental, health and safety matters, including reactor safety. In congressional testimony on April 25, 1991, the GAO stated in part:

> "In the past we have testified many times before this committee regarding problems in the Department of Energy (DOE). It is a pleasure to be here today to discuss a positive program in DOE. In summary, Mr. Chairman, we have reviewed the environmental, health, and safety practices at the Naval Reactors laboratories and sites and have found no significant deficiencies."

2 Naval Nuclear Powered Ships

2.1 Background

The source of energy for Naval nuclear powered ships originates from fissioning uranium atoms contained within pressurized water reactor cores. Since the fission process also produces radiation, shielding is placed around the reactor to protect the crew. U.S. Naval nuclear propulsion plants, including SEAWOLF class submarines, use a pressurized water reactor design which has two basic systems: the primary system and the secondary system. The arrangement is shown schematically in Figure 1. The primary system circulates ordinary demineralized water in an all-welded, closed loop consisting of the reactor vessel, piping, pumps and steam generators. The heat produced in the reactor core is transferred to the water, which is kept under pressure to prevent boiling. The heated water passes through the steam generators where it transfers its energy. The primary water is then pumped back to the reactor to be heated again.

Inside the steam generators, the heat from the primary system is transferred across a water-tight boundary to the water in the secondary system, also a closed loop. The secondary water, which is at a relatively low pressure, boils, creating steam. Isolation of the secondary system from the primary system prevents water in the two systems from intermixing, keeping radioactivity out of the secondary water.

In the secondary system, steam flows from the steam generators to drive the main propulsion turbines, which turn the ship's propellers, and the turbine generators, which supply the ship with electricity. After passing through the turbines, the steam is condensed back into water and feed pumps return it to the steam generators for reuse. Thus, the primary and secondary systems are separate, closed systems in which constantly circulating water transforms energy produced in the nuclear chain reaction into useful work.

The reactor core is installed in a heavy-walled pressure vessel

within a primary shield. This shield limits exposure from gamma and neutron radiation produced when the reactor is at power. Reactor plant piping systems are installed primarily inside a reactor compartment, which is surrounded by a secondary shield. Because of these two shields, the resulting radiation outside the propulsion plant spaces during reactor plant operation is generally not any greater than background radiation (references 1 and 5).

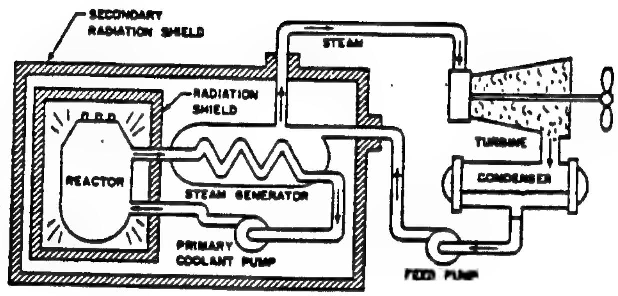

Figure 1: Pressurized Water Reactor

2.2 Reactor Design and Operation

U.S. nuclear-powered warships and their reactors are designed to exacting and rigorous standards. For submarines, this includes the ability to submerge to substantial depths. They must be able to survive battle shock well in excess of the forces that will be experienced during the shock test and protect crews in combat. Naval reactors include redundant systems and means of auxiliary propulsion, and are operated by highly trained crews using rigorously applied procedures.

The nuclear fuel in Naval nuclear propulsion reactor cores uses highly corrosion-resistant and highly radiation-resistant materials. The resistance to corrosion is such that the reactor core could remain submerged in seawater indefinitely without releasing fission products while the radioactivity decays, since the corrosion rate of the protective cladding on the fuel elements is negligible. As a result, the fuel is very strong and has very high integrity. The fuel is designed, built, and tested to ensure that the radioactive

fission products during normal reactor operations or adverse conditions will be contained. Naval nuclear fuel can withstand combat shock loads that are well in excess of 50 times the force of gravity and over twice the forces that would be experienced in a ship shock test. Naval nuclear fuel routinely operates with rapid changes in power level since Naval ships must be able to change speed quickly in operational situations. Naval nuclear fuel consists of solid components which are non-explosive, non-flammable, and non-corrosive.

Strict adherence to conservative principles of design and operation of Naval reactors was discussed on May 24, 1979, by the Director of Naval Nuclear Propulsion (then Admiral H. G. Rickover) in Congressional testimony following the accident at Three Mile Island. Rickover emphasized that ensuring reactor safety is the responsibility of all personnel who work on Naval nuclear propulsion plants and that each Program element from training, to design, to construction, and to operation must be properly carried out in a coordinated fashion to achieve the goal of safe performance. A more thorough discussion of this topic can be found in *Rickover and the Nuclear Navy: The Discipline of Technology* (Duncan 1990).

3 Impacts of Normal Operations

Nearly all (greater than 99%) of the radioactive atoms in a nuclear reactor are found in two forms: the uranium fuel itself or fission products created by the nuclear chain reaction. As discussed above, the fuel elements in Naval propulsion reactor cores are designed and built with high fuel integrity to retain this radioactivity. This high fuel integrity has been confirmed by operating experience. Such integrity is a necessity for sailors who must live in the enclosed atmosphere of a submarine. High integrity fuel is also used for nuclear powered surface ships.

The quantity (less than 1%) of remaining radioactive atoms present in a Naval nuclear reactor are encountered in two forms. The majority (99.9%) of the remaining (1%) radioactive atoms form an integral part of the structural alloys of the reactor plant piping and components, created by neutron activation of the iron and alloying elements during operation of the reactor plant. The balance (0.1%) is in the form of finely divided radioactive corrosion and wear products originating from metal surfaces in contact with reactor coolant. These corrosion and wear products are transported in the reactor coolant through the nuclear fuel region where they are activated by neutrons, and then deposited on piping system internal surfaces. Most of these corrosion products tightly adhere to piping system internal surfaces. The small amount which does not adhere is the source of potential radioactive contamination encountered during work on Naval nuclear reactor

plants. Stringent controls are used to keep this material contained when working on system internals. Moreover, naval reactor plants have systems which continuously purify the reactor coolant and remove such contamination.

4 Radiological Environmental Monitoring Program

Radiological environmental monitoring is conducted by the U.S. Navy in U.S. harbors frequented by Naval nuclear powered ships, including comprehensive marine, air, and land-based environmental contamination and radiation sampling. The Navy issues an annual report which describes the Navy's policies and practices regarding such things as disposal of radioactive liquid, transportation and disposal of radioactive materials and solid wastes, and monitoring of the environment to determine the effect of nuclear-powered warship operations (reference 5). This report is provided to Congress and to cognizant Federal, State, and local officials in areas frequented by nuclear-powered ships. Reference 5 reports that the total amount of long-lived gamma radioactivity released into harbors and seas within twelve miles of shore for all Navy nuclear powered ships has been less than 0.002 curies during each of the last twenty-three years. The Code of Federal Regulations (10CFR20) lists water concentration limits for discharge of radioactivity for commercial nuclear facilities in effluents based on limiting the dose of members of the public from continuous ingestion of the activitv discharged to 50 millirem per year. This limit is given for information only. Navy policy is to reuse radioactive water. As a result, the control of radioactive liquid discharges at Navy facilities is much more stringent than at facilities such as commercial nuclear power plants which comply with the limits of 10CFR20. The amount of radioactivity (less than 0.002 curies) discharged from all Navy nuclear powered vessels annually within 12 miles of shore combined is less than one hundredth of the amount of radioactivity released by a single typical commercial nuclear power plant under its Nuclear Regulatory Commission license. To put this small quantity of radioactivity into perspective, it is less than the quantity of naturally occurring radioactivity in the volume of harbor water occupied by a single naval nuclear powered submarine.

As a measure of the significance of this data, if one person were able to drink the entire amount of radioactivity discharged into any harbor in any of the last twenty-three years by U.S. nuclear powered warships and support facilities, that person would not exceed the annual radiation exposure permitted for an individual worker by the U.S. Nuclear Regulatory Commission.

Environmental samples from each harbor monitored are also independently checked at least annually by a U.S. Department of Energy laboratory to ensure that analytical procedures are

correct and standardized. Additionally, the U.S. Environmental Protection Agency has conducted independent surveys in U.S. harbors; reference 5 lists each report issued by the EPA on their surveys. The results are consistent with Navy monitoring results. These surveys have confirmed that U.S. Naval nuclear powered ships and their support facilities have had no significant impact on the radioactivity of the marine or terrestrial environment.

5 Occupational Radiation Exposure

The Naval Nuclear Propulsion Program invokes stringent controls on occupational radiation exposure. As discussed in reference 4, the Program's policy is to reduce to as low as reasonably achievable the exposure to personnel from ionizing radiation associated with Naval nuclear propulsion plants. These stringent controls on occupational radiation exposure have been successful. No civilian or military personnel in the Naval Nuclear Propulsion Program have ever exceeded the Federal accumulated radiation exposure limit which allows 5 roentgen-equivalent-man (rem) exposure for each year beyond age 18. Since 1967, no person has exceeded the Federal limit which allows up to 3 rem per quarter year, nor in this period has anyone exceeded the limit of 5 rem per year for radiation associated with Naval nuclear propulsion plants (Note: the Navy has used a self-imposed limit of 5 rem/year since 1967; the NRC established 5 rem/year as a Federal Annual Radiation Exposure limit on January 1, 1994 (10CFR20)). No person in the Naval Nuclear Propulsion Program has received greater than two rem in a year since 1980. In recent years, the average occupational exposure of each person monitored at all shipyards is 0.12 rem per year. For comparison, the amount of radiation exposure a typical person in the United States receives each year from natural background radiation is 0.300 rem. The average lifetime accumulated radiation exposure from radiation associated with Naval nuclear propulsion plants for all shipyard personnel is 1.2 rem.

In reference 7 the National Council on Radiation Protection and Measurements reviewed the exposures to the U.S. working population from occupational exposures. This included a review of the occupational exposures to personnel from the Naval Nuclear Propulsion Program. Based on this review, the National Council on radiation Protection and Measurements concluded:

> "These small values (of occupational exposure) reflect the success of the Navy's efforts to keep doses as low as reasonably achievable (ALARA)."

The propulsion spaces and crew of SEAWOLF class submarines are approximately the same size as those of LOS ANGELES class submarines. The radiation exposure due to operation and

maintenance of SEAWOLF class submarines would also be similar to those of LOS ANGELES class submarines, thus, occupational exposure from SEAWOLF class submarines will not impose any additional risk beyond that already accepted for previous submarine classes.

6 Naval Nuclear Propulsion Plant Safety

The safety record of United States naval nuclear propulsion plants aboard nuclear-powered warships is well known; there has never been a reactor accident since the first naval reactor began operation, comprising over 4,600 reactor years of experience. As cited earlier, U.S. Navy nuclear-powered warships have steamed over 100 million miles since 1955. A number of reasons why the design and operation of Naval nuclear powered ships result in minimal risk of accidents, and why the consequences would be small should a problem occur are briefly discussed below.

Critical to safety are the officers and sailors who operate the naval nuclear propulsion plants aboard nuclear powered warships. Since the 1950's, over 91,000 officers and enlisted technicians have been trained for this purpose. The officer selection process accepts only applicants who have high standing at colleges and universities. All personnel receive one to two years of training in theoretical knowledge and practical experience on operating reactors that are like the reactors used on ships. Even after completing this training, before manning a nuclear propulsion plant watch station, the personnel must spend about six months qualifying on the ship to which they are assigned. Despite the extensive training and qualification program, multiple layers of supervision and inspection are employed to ensure a high state of readiness and compliance with safety standards. When a ship's reactor is in operation at sea, there are, in addition to the enlisted technicians, four officers on duty, with an average total of 40 years of experience in naval nuclear propulsion.

As discussed earlier, all U.S. nuclear-powered warships use pressurized water reactors. The radioactive fission products are contained within high-integrity fuel elements that can withstand battle shock well in excess of 50 times the force of gravity which is over twice the forces that would be experienced during a shock test. The fuel is designed to preclude release of fission products to the primary coolant. Only limited radioactivity is found in the pure water used in the all-welded primary coolant system. The reactor compartment forms a container and shields the crew from radiation. This compartment is radiologically clean so that it can be entered without any protective clothing within minutes of shutting down the reactor.

As discussed in section 7, all previous Naval nuclear propulsion plants that have been shock tested have performed as designed resulting in no release of fission products from Naval reactor cores to the environment. Even in the highly improbable event that the ship should sink and flood as a result of the shock test (note that since the test is conducted in relatively shallow water (500 feet) the hull would not be crushed due to sea pressure), substantial data exist verifying the high integrity of U.S. Naval reactor designs. Two nuclear-powered submarines (USS THRESHER and USS SCORPION) sank during operations at sea in the 1960's. Neither was lost due to a reactor accident, but both losses resulted in the ship exceeding crush depth and the hull being crushed inward by tremendous sea pressure, events producing far more damage to the ships than would occur at the shallow depth in which the shock test would be performed. Radiological surveys of the debris sites have been performed on several occasions over the past three decades and confirm that, despite the catastrophic manner in which these ships were lost, no detectable radioactive fission products have been released into the environment. The only radioactivity found at these sites was from corrosion products from the primary coolant system. The amount of radioactivity found in the surveys was less than the naturally occurring radioactivity in the seabed sediment. These data are reported in detail in separate publicly available reports (references 8 and 9). Likewise, if SEAWOLF were to rest on the sea floor intact, there would be sufficient time to place the reactor plant in a long term stable condition without impacting the surrounding environment.

In addition to the many safety considerations referred to above, there are several other factors that enhance naval reactor safety. Naval reactors include many redundant systems and means of auxiliary power. Naval reactors are smaller and lower in power rating than typical commercial plants. They also normally operate at power levels well below their rated power. Thus, the amount of radioactivity potentially available for release typically is less than one hundredth of that for a commercial reactor. The plant is designed to withstand a wide variety of casualty conditions without damage to the reactor core or release of significant amounts of radioactivity.

In addition, consistent with past practice, the SEAWOLF Class nuclear propulsion plant design was independently reviewed by the Nuclear Regulatory Commission (NRC) and the Advisory Committee on Reactor Safeguards (ACRS). Both reviews concluded that the SEAWOLF Class reactors could be operated without undue risk to the health and safety of the public.

7 Previous Shock Tests of Nuclear Powered Warships

All U.S. warships are designed to withstand extreme shock from underwater explosions. For most structure and equipment, the shock design loads result in stronger, more robust structure and equipment than would be required to satisfy other design requirements, such as mechanical, pressure or thermal loads. Similarly for electrical and electronic equipment, shock hardened designs are less susceptible to signal or power disruption. In a non-shock environment, such shock hardened equipment provides increased margin to degradation and failure.

The shock capability of individual equipment is confirmed by testing individual equipment at design shock loads. The primary focus of a shock test of the entire ship is not to test equipment at or near or its breaking point. Rather, the purpose is to carefully measure, record, and analyze the reaction of equipment in actual shipboard condition to shock impulses, and to compare these results to analytical predictions made before the test. Five nuclear submarines (USS SKATE (SSN 578), USS SKIPJACK (SSN 585), USS THRESHER (SSN 593), USS OMAHA (SSN 692) and USS JACKSONVILLE (SSN 699)) and two nuclear surface ships (USS ARKANSAS (CGN 41) and USS THEODORE ROOSEVELT (CVN 71)) have been subjected to underwater explosion shock tests similar to that proposed for SEAWOLF. The maximum severity of the shock tests were less than 2/3 of the shock design requirements for shipboard equipment. As expected, in none of these tests was the safety of the nuclear reactor jeopardized, and no radiological problems were experienced. The maximum severity of the proposed ship shock test for SEAWOLF will be 1/2 of the shock design requirements.

The design and testing of SEAWOLF equipment and structures for shock is more thorough than for any previous submarine class. Lessons from previous equipment shock tests, and previous submarine shock tests have been factored into the SEAWOLF design. For the nuclear propulsion plant, this not only includes the reactor core and reactor coolant pressure containing boundary, but all essential auxiliary equipment which supports, monitors, and controls the propulsion plant. Based on past successful shock test performance and the enhanced design features of the SEAWOLF submarine, no radiological impacts are expected as a result of completing the shock test.

8 Conclusions

The Naval Nuclear Propulsion Program provides comprehensive technical management of all aspects of Naval nuclear propulsion plant design, construction and operation including careful consideration of reactor safety, radiological, and environmental concerns. Past operations, including previous

shock tests, have resulted in no significant radiological environmental impacts and demonstrated the Program's effectiveness of this management philosophy. Continued application of the environmental practices which are standard throughout the Program will ensure the absence of any radiological environmental effect as a result of shock testing or operating the SEAWOLF submarine.

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8. Knolls Atomic Power Laboratory KAPL-4749, *Deep Sea Radiological Environmental Monitoring Conducted at the Site of the Nuclear-Powered Submarine SCORPION Sinking*, R.B. Sheldon and J.D. Michne, October, 1993.

9. Knolls Atomic Power Laboratory KAPL-4748, *Deep Sea Radiological Environmental Monitoring Conducted at the Site of the Nuclear-Powered Submarine THRESHER Sinking*, R.B. Sheldon and J.D. Michne, October, 1993.

10. Code of Federal Regulations, Title 10 (Nuclear Regulatory Commission), Part 20, *Standards for Protection Against Radiation*.

APPENDIX G

BIOLOGICAL ASSESSMENT INFORMATION

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APPENDIX G
BIOLOGICAL ASSESSMENT INFORMATION

G.1 INTRODUCTION

In accordance with Section 7 of the Endangered Species Act, the Navy has contacted the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) concerning listed species potentially affected by the proposed action. Copies of the Department of the Navy, NMFS, and USFWS informal consultation letters written prior to preparation of the DEIS are provided in Appendix C. Based on the responses, no formal consultation with the USFWS will be required because there are no endangered and threatened species or critical habitats under USFWS jurisdiction that could be affected by the proposed action (i.e., the USFWS has already completed its responsibilities under the Endangered Species Act). However, formal consultation with the NMFS will be required.

The DEIS serves as a Biological Assessment which the Navy has submitted to the NMFS to initiate formal consultation. The purpose of the Biological Assessment is "to evaluate the potential effects of the action on listed and proposed species and designated and proposed critical habitat and determine whether any such species or habitat are likely to be adversely affected by the action" (50 CFR 402.12). The DEIS as a whole provides all of the information required for a Biological Assessment. This appendix gathers the most pertinent information in one place for the convenience of reviewers. Within this appendix, reference is made, where necessary, to other DEIS sections and appendices which provide further details.

The Biological Assessment takes into account the views of recognized experts as indicated by the personal communications listed in the Literature Cited section. Marine mammal and turtle experts, including NMFS scientists, were consulted during preparation of the species descriptions and the aerial survey design. The framework for impact analysis was reviewed by marine mammal, sea turtle, and acoustics experts.

G.1.1 Proposed Action and Geographic Location

The proposed action is to shock test the SEAWOLF submarine at an offshore location. The DEIS focuses on alternative areas offshore of Mayport, Florida and Norfolk, Virginia (**Figure G-1**). The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity sometime between 1 April and 30 September 1997. If the Mayport area is selected, the shock tests would be conducted between 1 May and 30 September 1997 to minimize risk to sea turtles, which are more abundant at the Mayport area during April. The shock tests would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems prior to the submarine experiencing the next level of shock intensity.

As indicated below in the alternatives discussion, Mayport has been identified as the preferred area for SEAWOLF shock testing based on its lower density of marine mammals. However, to be consistent with the impact analysis of alternative areas

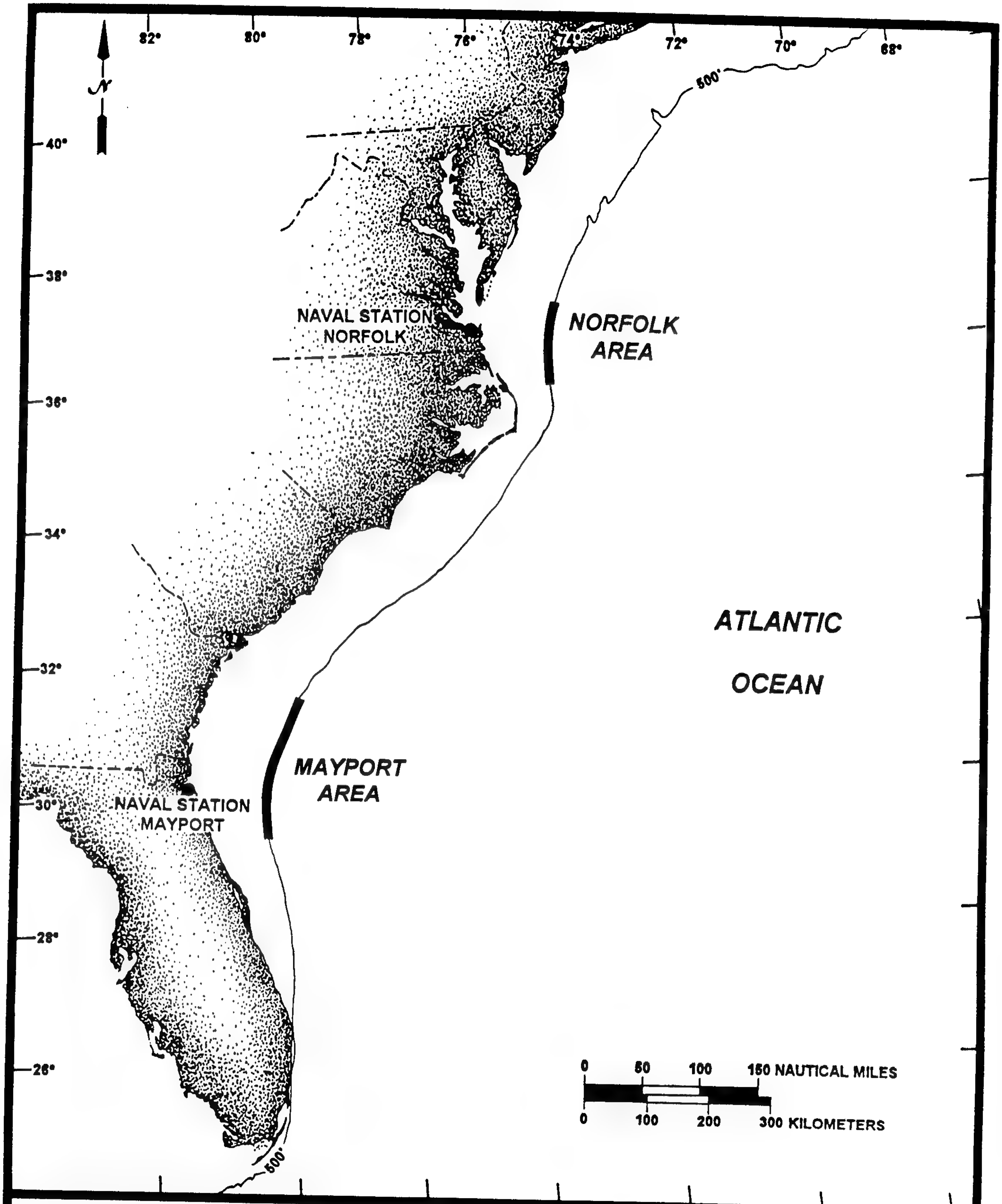


Figure G-1. Location of the Mayport and Norfolk areas for SEAWOLF shock testing.

presented in the DEIS, the Biological Assessment discusses both the Mayport and Norfolk areas.

G.1.2 Alternatives Evaluated

Section 2 of the DEIS presents a detailed analysis of alternatives. The DEIS evaluates a "no action" alternative and alternative areas for the proposed shock testing. Alternative offshore areas for shock testing are compared from operational and environmental perspectives. A preferred alternative is selected based on these comparisons. A synopsis of the alternatives analysis is presented below.

G.1.2.1 No Action

Under the "no action" alternative, no new activities affecting the physical environment would be conducted to predict the response of SEAWOLF class submarines to underwater detonations. This alternative would by definition avoid all environmental impacts of shock testing.

As described in Section 1.1 of the DEIS, the Navy has established a Live Fire Test and Evaluation (LFT&E) program to complete the survivability testing of the SEAWOLF class submarines. The program consists of three major areas which together provide the data necessary to assess the SEAWOLF's survivability: computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. The SEAWOLF LFT&E program already includes the maximum reasonable amount of computer modeling and component testing. Only by testing the entire ship manned with the appropriate systems operating can the shock response of the entire ship, including the interaction of ship systems and components, be obtained and an adequate assessment of the survivability of the submarine be determined in accordance with 10 USC 2366. The intent of 10 USC 2366 is to ensure that the combat survivability of the weapon system (submarine) is assessed before the system is exposed to hostile fire. The information obtained during the shock test is used to improve the shock resistance of the ship and therefore reduce the risk of injury to the crew. The "no action" alternative would prevent the Navy from being able to make the survivability assessment required by 10 USC 2366.

As the "no action" alternative involves no activity affecting the physical environment, it is not individually analyzed further in the DEIS. The "no action" alternative is implicit in the environmental analysis throughout the document. The Existing Environment section provides a "no action" benchmark against which the proposed action can be evaluated. The Environmental Consequences section compares impacts of an action (shock testing) with the alternative of "no action."

G.1.2.2 Alternative Areas for the Proposed Action

The remaining alternative discussed is the proposed action, which is to shock test the SEAWOLF at an offshore location. Several possible general areas for shock testing were evaluated by the Navy, as described below. The final, specific site for shock testing would not be selected until 2 to 3 days before the test based on marine mammal and turtle surveys (see Section 5.0). However, the Navy has identified general offshore

areas which meet certain operational criteria, and has a preferred area. The final test site would be selected within the preferred area if this alternative is selected.

Operational Requirements

Alternative areas for shock testing the SEAWOLF were evaluated by the Navy according to operational criteria. A location on the east coast would best meet the Navy's operational needs because that is where the SEAWOLF will be homeported and where all sea trials will occur. A suitable area must have a water depth of 152 m (500 ft) and be within 185 km (100 nmi) of a naval station support facility and a submarine repair facility (including a drydock capable of supporting SEAWOLF class submarines) and within 370 km (200 nmi) of an ordnance storage/loading facility. Calm seas and good visibility are needed, and there must be little or no ship traffic in the area.

Five east coast areas were identified that could meet the Navy's operational requirements to some extent: Mayport, Florida; Norfolk, Virginia; Groton, Connecticut; Charleston, South Carolina; and Key West, Florida. Charleston was eliminated because of the closure of the Charleston Navy Yard and Charleston Naval Station under the Base Closure and Realignment (BRAC) process (i.e., facilities and vessels to support the test would not be available). The water depth at the Key West area is too great for the planned shock testing. In addition, the Key West area lacks the industrial base to support submarine repairs or drydocking, and there is no surface vessel homeport nearby which could provide Navy assets (ships and planes) to support the test. The three remaining areas (Mayport, Norfolk, and Groton) were compared with respect to operational criteria. The analysis showed that only the Mayport and Norfolk areas meet all of the Navy's operational requirements and that these two areas are rated as nearly equal. Only the Mayport and Norfolk areas are included in the detailed environmental analysis in the DEIS.

Environmental Considerations

At both the Mayport and Norfolk areas, possible test sites were first defined as any point along the 152 m (500 ft) depth contour within 185 km (100 nmi) of a naval station support facility and a submarine repair facility. Environmental features near each area were mapped, including marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, and critical habitat for endangered or threatened species. Buffer zones were developed to avoid impacts to these areas and associated biota. Portions of the 152 m (500 ft) depth contour were excluded as summarized below.

At the Mayport area, there are no marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, or critical habitat areas. Therefore, all points along the 152 m (500 ft) depth contour are considered potential shock testing locations (**Figure G-2**).

At the Norfolk area, the portion of the 152 m (500 ft) depth contour passing through the proposed Norfolk Canyon Marine Sanctuary, along with a 4.6 km (2.5 nmi) buffer on either side, was excluded. The entire area north of the proposed sanctuary was eliminated due to the presence of several shipwrecks near the area. All remaining points

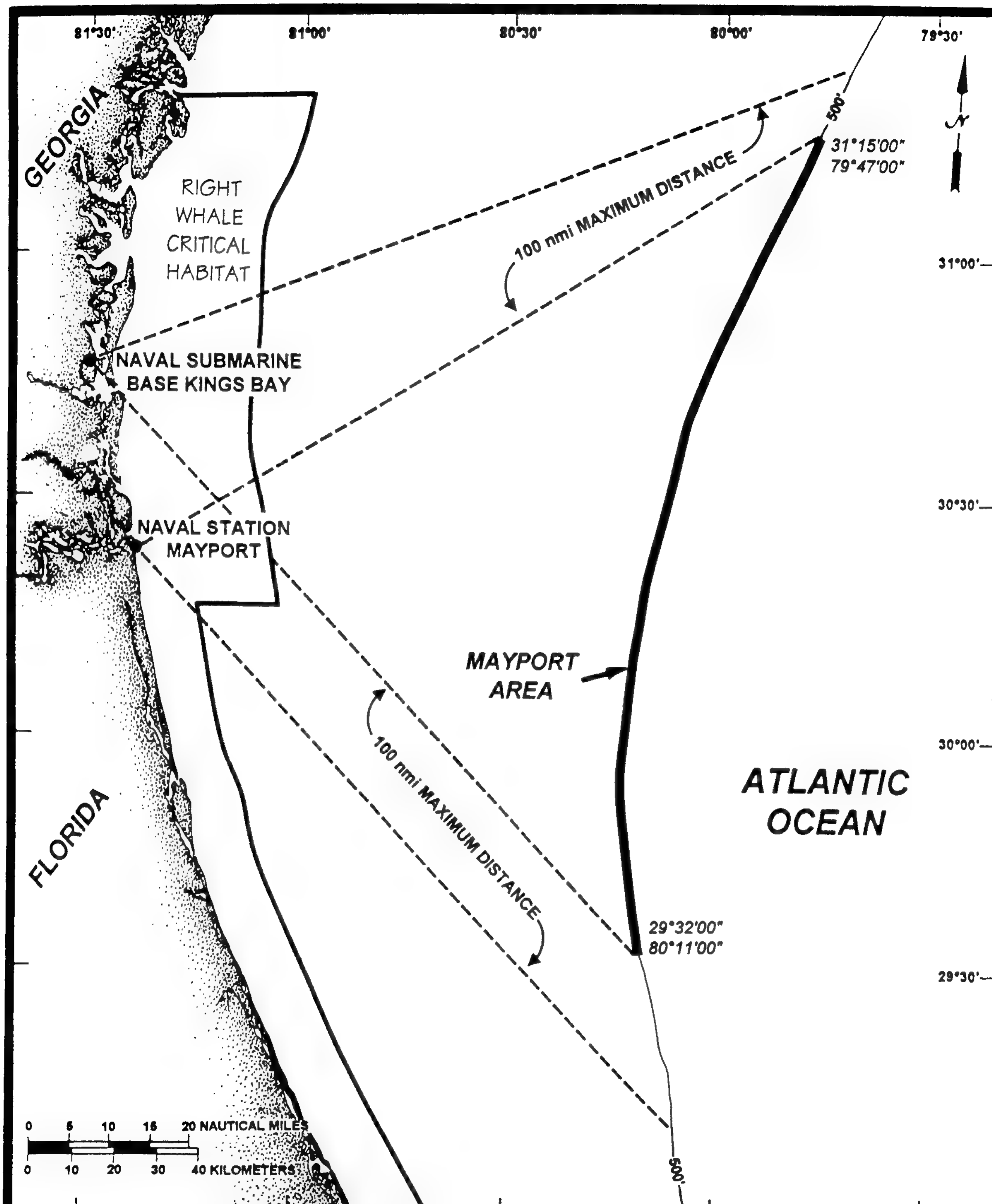


Figure G-2. The Mayport area. The area includes all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of Naval Station Mayport and Naval Submarine Base Kings Bay.

along the 152 m (500 ft) depth contour are considered potential shock testing sites (**Figure G-3**).

G.1.2.3 Preferred Alternative

The preferred alternative is to shock test the SEAWOLF submarine offshore of Mayport, Florida, between 1 May and 30 September with mitigation to minimize risk to marine mammals and turtles. This alternative meets the project purpose and need, satisfies operational criteria, and minimizes environmental impacts. The Norfolk area also meets the project purpose and need and satisfies operational criteria; however, the higher density of marine mammals in the area could increase the risk of impacts.

G.1.3 Mitigation Measures Included in the Proposed Action

The proposed action includes mitigation designed to minimize risk to marine mammals and turtles. The main mitigation measures include (1) a schedule shift at Mayport (no testing in April to avoid higher densities of sea turtles); and (2) a detailed marine mammal and sea turtle mitigation plan that includes site selection and pre- and post-detonation monitoring. The marine mammal and sea turtle mitigation plan is summarized below and described in detail in Section 5.0 of the DEIS. Other mitigation measures described in the DEIS (but not directly relevant to the Biological Assessment) include environmental buffer zones to avoid impacts to certain environmental features; an exclusion zone to avoid impacts to routine vessel and air traffic; and measures to deal with unexploded ordnance in the unlikely event of a misfire.

G.1.3.1 Schedule Shift to Avoid High Turtle Densities at Mayport

Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September 1997. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

G.1.3.2 Marine Mammal and Sea Turtle Mitigation Plan

A detailed Marine Mammal and Sea Turtle Protection/Mitigation Plan is presented in Section 5.0. The plan includes the same type of mitigation and monitoring efforts that were used successfully during the shock trial of the USS JOHN PAUL JONES in 1994. Those shock trial operations included two 4,536 kg (10,000 lb) detonations and resulted in no deaths or injuries of marine mammals (Naval Air Warfare Center, 1994), despite observed marine mammal population densities that were about 3 times greater than at the Norfolk area and about 25 times higher than at the Mayport area (Department of the Navy, 1993).

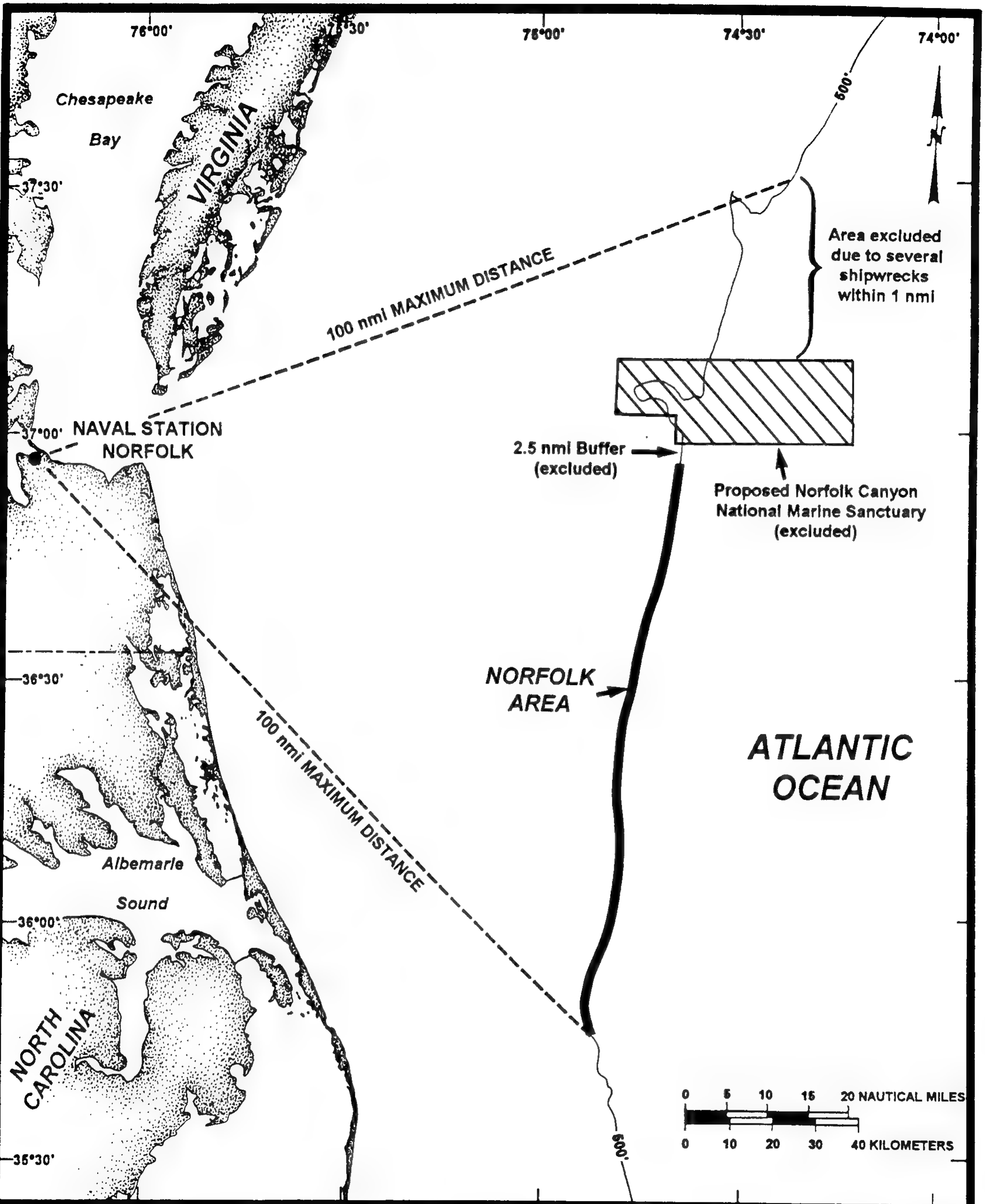


Figure G-3. The Norfolk area. The area includes all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of Naval Station Norfolk, except the excluded areas indicated.

The mitigation plan represents the final step in a sequence of actions to avoid or reduce environmental impacts. The Mayport and Norfolk areas were initially selected based on the Navy's operational requirements. Then, portions of the Norfolk area were excluded based on environmental considerations, as noted above. The schedule for testing at Mayport was shifted to avoid high turtle densities which may occur during April. Finally, the results of impact analysis in the Environmental Consequences section were used to identify a preferred alternative area (Mayport) based on the lower density of marine mammals.

The mitigation plan would build upon these previous efforts to avoid or reduce environmental impacts. The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If post-detonation monitoring showed that marine mammals or turtles were killed or injured as a result of a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

The concept of a ***safety range*** is integral to the mitigation plan. Detonation would be postponed if marine mammals or turtles were detected within the safety range radius of 3.8 km (2.05 nmi) around the detonation point. If turtles were found within the safety range, they would be removed and temporarily held in a sun-protected area on the deck of the MART vessel until after the detonation (see Section 5.0). The radius of the safety range is based on the maximum distance for non-lethal injury to a marine mammal and is more than twice the maximum distance for lethality to marine mammals and turtles. A 1.8 km (0.95 nmi) ***buffer zone*** has also been added to the safety range to accommodate the possible movement of animals into the safety range. That is, the area encompassed within a 5.6 km (3 nmi) radius from the detonation point would be monitored in an effort to detect any marine mammals or turtles approaching the safety range.

The mitigation plan includes three components: (1) aerial surveys/monitoring; (2) shipboard monitoring from the operations vessel and the Marine Animal Recovery Team (MART) vessel; and (3) passive acoustic monitoring using the Marine Mammal Acoustic Tracking System (MMATS). Aerial and shipboard monitoring teams would identify and locate animals on the surface, whereas the acoustic monitoring team would detect and locate calls from submerged animals. This combination of monitoring components would be used to detect marine mammals or turtles within the safety range and to minimize the risk of impacts to these animals.

For further information about the Marine Mammal and Sea Turtle Mitigation Plan, see Section 5.0 of the DEIS.

G.2 SPECIES OCCURRENCE AND STATUS

The following sections provide species descriptions of marine mammals and sea turtles which are currently listed as endangered or threatened, or are proposed for listing. Topics evaluated in each of the following descriptions include summaries of available life history information and population dynamics, including status, distribution, and current range. When appropriate, a discussion of critical habitat is presented.

G.2.1 Listed Marine Mammals

Based on a review of historical sighting records, a total of six species of endangered whales may be found at the Mayport or Norfolk areas (**Table G-1**). Five of these are baleen whales: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), northern right whale (*Eubalaena glacialis*), and sei whale (*Balaenoptera borealis*). The only listed toothed whale species is the sperm whale (*Physeter macrocephalus*).

G.2.1.1 Blue Whale

Blue whales *(Balaenoptera musculus)* range from the Arctic to at least mid-latitudes including the waters of the Gulf of Mexico. This species is pelagic, primarily found feeding north of the Gulf of St. Lawrence during spring and summer. It is considered as a very occasional species in waters off the eastern U.S. (Blaylock et al., 1995). Limited migration has been documented south to subtropical waters during fall and winter. This species feeds on krill and copepods, the abundance of which most likely controls migration in and out of polar areas. Mating and calving occurs in late fall and winter. Gestation lasts 10 to 11 months. Calves are born every 2 to 3 years. Blue whales are usually seen solitary or in groups of 2 or 3 individuals. Existing data are insufficient for stock differentiation and population estimates in the Atlantic (Blaylock et al., 1995).

G.2.1.2 Fin Whale

Fin whales *(Balaenoptera physalus)* range from the Arctic to the Greater Antilles, including the Gulf of Mexico. They are usually found inshore of the 2,000-m (6,562-ft) contour. This species occurs widely in the middle Atlantic throughout the year, with concentrations from Cape Cod north in summer and from Cape Cod south in winter. This species is frequently found along the New England coast from spring to fall in areas of fish concentration. It is thought that fin whales migrate north nearshore along the coast during spring and south offshore during winter. This species feeds on krill, planktonic crustaceans, and schooling fish such as herring and capelin. It is believed that fin whales breed in the middle Atlantic, with mating and calving occurring from November to March. Gestation lasts about 1 year and calves are suckled for 7 months. Fin whales off the eastern U.S. to Canada constitute a single stock (Blaylock et al., 1995). The minimum population estimate for this species in the western Atlantic was 1,704 individuals, based on a 1991-92 shipboard survey (Blaylock et al., 1995).

Table G-1. Status and historical presence of marine mammals and sea turtles that are currently listed or proposed for listing which may occur in the Mayport and Norfolk areas.

Common and Scientific Name	Status[a]	Historical Presence[b]	
		Mayport	Norfolk
MARINE MAMMALS			
Blue whale (*Balaenoptera musculus*)	E	+	+
Fin whale (*Balaenoptera physalus*)	E	+	++
Humpback whale (*Megaptera novaeangliae*)	E	+	++
Northern right whale (*Eubalaena glacialis*)	E	+	+
Sei whale (*Balaenoptera borealis*)	E	+	++
Sperm whale (*Physeter macrocephalus*)	E	+	+
Bottlenose dolphin (*Tursiops truncatus*)	PT	++	++
Harbor porpoise (*Phocoena phocoena*)	PT	--	+
SEA TURTLES			
Green sea turtle (*Chelonia mydas*)	T/E[c]	+	+
Hawksbill sea turtle (*Eretmochelys imbricata*)	E	+	+
Kemp's ridley sea turtle (*Lepidochelys kempii*)	E	+	+
Leatherback sea turtle (*Dermochelys coriacea*)	E	++	++
Loggerhead sea turtle (*Caretta caretta*)	T	++	++

[a] Status: E = endangered species, PT = proposed for listing as a threatened species. The PT designation for the bottlenose dolphin applies only to the coastal migratory population, which is not likely to occur at either offshore area.

[b] Historical Presence: ++ = presence probable based on historical sightings data; + = presence possible based on historical sightings data, but a depth or latitudinal limit may exist; -- = presence not expected based on historical sightings data. Sources for marine mammals: Leatherwood et al., 1976; CETAP, 1982; Duffield et al., 1983; Payne et al., 1984; Lee, 1985; Duffield, 1986; Kenney et al., 1986; Winn et al., 1986; Kenney and Winn, 1987; Kraus et al., 1988, 1993; Knowlton and Kraus, 1989; Manomet Bird Observatory, 1989; Hersh and Duffield, 1990; Kenney, 1990; Mayo and Marx, 1990; DOI, MMS, 1990; Kraus and Kenney, 1991; Mitchell, 1991; NMFS, 1991a,b; Payne and Heinemann, 1993; Schaeff et al., 1993; Blaylock and Hoggard, 1994. Sources for sea turtles: Prichard and Marquez, 1973; Schwartz, 1978; Carr et al., 1979; Crouse, 1980, 1988; Lee and Palmer, 1981; CETAP, 1982; Murphy and Hopkins, 1984; Musick et al., 1984; Lee, 1985; Lund, 1985; Lutcavage and Musick, 1985; Musick, 1986; Henwood and Ogren, 1987; Schroeder and Thompson, 1987; Dodd, 1988; Epperly and Veishlow, 1989; Knowlton and Weigle, 1989; Continental Shelf Associates, Inc., 1990; Marquez, 1990; NMFS and USFWS, 1991a,b, 1992a,b, 1993; USFWS, 1991; Meylan, 1992; Thompson and Huang, 1993.

[c] Green sea turtles are listed as threatened except for Florida where breeding populations are listed as endangered.

G.2.1.3 Humpback Whale

Humpback whales *(Megaptera novaeangliae)* range from the Arctic to the West Indies, including the Gulf of Mexico. They are found in middle Atlantic shallow coastal waters during spring and in waters around Cape Cod to Iceland during late spring to fall. During summer there are at least five geographically distinct feeding aggregations in the northern Atlantic. Generally, their distribution has been largely correlated to prey species and abundance (Blaylock et al., 1995). It is thought that migration south to the Caribbean occurs during fall. This species feeds largely on euphausiids and small fish such as herring, capelin, and sand lance. Calving and breeding occurs in the Caribbean from January to March. Gestation lasts 10 months and calves are suckled for about 11 months. Critical habitats have been identified in the western Gulf of Maine and the Great South Channel (Massachusetts). The minimum population estimate for the North Atlantic range of the humpback whale is 4,865 individuals (Blaylock et al., 1995).

G.2.1.4 Northern Right Whale

Northern right whales *(Eubalaena glacialis)* range from Iceland to eastern Florida, with occasional sightings in the Gulf of Mexico. This is the rarest of the world's baleen whales, with a current North Atlantic population between 325 and 350 individuals (Kraus et al., 1993). Coastal waters of the southeastern United States (off Georgia and northeast Florida) are important wintering and calving grounds for northern right whales, while the waters around Cape Cod and Great South Channel are used for feeding, nursery, and mating during summer (Kraus et al., 1988; Schaeff et al., 1993). From June to September, most animals are found feeding north of Cape Cod. Right whale mating probably occurs during late summer; gestation lasts 12 to 16 months, and calves are suckled for about one year (Knowlton and Kraus, 1989). Southward migration occurs offshore from mid-October to early January, although right whales may arrive off the Florida coast as early as November and may stay into late March (Kraus et al., 1993). Migration northward along the coast of Florida takes place between early January and late March. Coastal waters off the Carolinas may represent a migratory corridor for this species (Winn et al., 1986; Kraus et al., 1993). It has been suggested that during the spring migration, right whales typically transit offshore North Carolina in shallow water immediately adjacent to the coast; fall migrations may occur further offshore in this region (Department of the Interior, Minerals Management Service, 1990). This species usually occurs shoreward of the 200-m (656-ft) contour line. Preferred water depths during recent surveys off the Florida coast range from 3 to 73 m (10 to 240 ft), with a mean of 12.6 m (41.3 ft) (Kraus et al., 1993).

Designated critical habitat for the northern right whale includes portions of Cape Cod Bay and Stellwagen Bank and the Great South Channel (off Massachusetts) and waters adjacent to the coasts of Georgia and northeast Florida (Federal Register 59(106):28793-28808). The southernmost critical habitat (**Figure G-2**) encompasses "waters between 31°15'N (i.e., near the mouth of Altamaha River, Georgia) and 30°15'N (i.e., near Jacksonville, Florida) from the shoreline out to 15 nautical miles offshore, and the waters between 30°15'N and 28°00'N (i.e., near Sebastian Inlet, Florida) from the shoreline out to 5 nautical miles." The distance between the Mayport area and the right whale critical habitat ranges from 76 to 115 km (41 to 62 nmi).

G.2.1.5 Sei Whale

Sei whales *(Balaenoptera borealis)* range from south of the Arctic to northeast Venezuela, including the Gulf of Mexico. This species is considered to be pelagic and widely distributed from below polar seas to the Caribbean. It is believed that the following three main stocks occur: 1) Newfoundland/Labrador; 2) Nova Scotia; and 3) Caribbean/ Gulf of Mexico. The Nova Scotia stock migrates along the coast, with occurrence south of Cape Cod in winter and from Cape Cod north to the Arctic in summer. This species feeds on copepods, krill, and small schooling fish such as anchovies, sauries, and mackerel. Peak pairing is reported to be from November to February in temperate waters. Gestation lasts 1 year and calves are born in February in warmer waters. Calves are suckled for 6 months. Large numbers concentrate in feeding grounds but usually travel in groups of 2 to 5 individuals. Existing data are insufficient for obtaining estimates of population size in the Atlantic (Blaylock et al., 1995).

G.2.1.6 Sperm Whale

Sperm whales *(Physeter macrocephalus)* range from the Davis Straits to Venezuela, including the Gulf of Mexico. This species is pelagic, occurring along the continental shelf edge and slope, continuing into mid-ocean areas; it is occasionally found on the shelf. Sperm whales generally feed on mesopelagic (open ocean environment between 150 and 1,000 m [492 and 3,281 ft] depth) squid along the 1,000-m (3,281-ft) contour. North-south migratory routes observed through middle Atlantic areas are always inhabited. Females, calves, and juveniles remain south of 40°N to 42°N latitude throughout the year while mature males range to higher latitudes (68°N) during summer. This species is most abundant during spring. Mating season is prolonged, extending from late winter through early summer. Calves are born once every 3 to 6 years. Calving occurs between May and September in the northern hemisphere. Large, old males are solitary, while females, calves, and juveniles form "breeding schools" with 4 to 150 individuals. Young males form segregated bachelor groups, or "schools", of up to 50 individuals. The sperm whales which occur along the eastern U.S. represent only a fraction of the total stock. The nature of linkages of this habitat with others is unknown. Their minimum population estimate is 226 individuals (Blaylock et al., 1995).

G.2.2 Candidate Marine Mammals

Two additional marine mammal species, the bottlenose dolphin (*Tursiops truncatus*) and the harbor porpoise (*Phocoena phocoena*), have been proposed for listing as threatened.

G.2.2.1 Bottlenose Dolphin (Coastal Migratory Stock)

The coastal migratory stock of bottlenose dolphins (*Tursiops truncatus*) was proposed in August 1991 for designation as depleted under the Marine Mammal Protection Act. This designation was formally approved by the NMFS on 6 April 1993. In 1994, the NMFS proposed listing the coastal migratory stock as threatened under the Endangered Species Act. This proposed designation remains pending. Although bottlenose dolphins are likely to occur at either the Mayport or Norfolk area, the coastal migratory stock proposed for threatened status occurs predominantly in shallow, nearshore waters and is not likely to occur at either offshore area.

Bottlenose dolphins (*Tursiops truncatus*) in the western Atlantic range from Nova Scotia to Venezuela, as well as the waters of the Gulf of Mexico (Hansen and Blaylock, 1994). This species is distributed worldwide in temperate and tropical inshore waters. Middle Atlantic populations are represented by a hematologically and morphologically distinct offshore stock and coastal stock (Duffield et al., 1983; Duffield, 1986; Hersh and Duffield, 1990; Hansen and Blaylock, 1994). Aerial survey results reported by the Cetacean and Turtle Assessment Program (CETAP, 1982) and Kenney (1990) indicated the offshore stock extends along the entire shelf break from Georges Bank to Cape Hatteras during spring and summer. During fall, this distribution compressed towards the south, with fewer sightings in winter. According to Kenney (1990), the offshore stock is concentrated along the shelf break, extending beyond the shelf edge in lower concentrations. Peak average estimated abundance for the offshore stock occurred during fall and was estimated to be 7,696 individuals (Hansen and Blaylock, 1994). No abundance estimates are available for the offshore stock south of Cape Hatteras (Blaylock et al., 1995). Recent research has indicated that there are a variety of stock structures possible within the coastal Atlantic bottlenose dolphin population both north and south of Cape Hatteras. Blaylock and Hoggard (1994), reporting results from the Southeast Cetacean Aerial Survey (SECAS) study (i.e., continental shelf waters; Cape Hatteras, North Carolina to mid-Florida; Gulf of Mexico waters), developed abundance estimates for the shallow, warm water Atlantic bottlenose dolphin ecotype. The offshore distribution of coastal bottlenose dolphins south of Cape Hatteras has not been described. Blaylock and Hoggard (1994) noted, however, the possibility for coexistence of the coastal and offshore stocks inhabiting the edge of the outer continental shelf and slope waters south of Cape Hatteras. Bottlenose dolphins feed on shrimp and fish. Mating and calving occur from February to May in Florida waters. The calving interval is 2 to 3 years. They are found in groups of up to several hundred individuals with group sizes increasing with distance from shore.

G.2.2.2 Harbor Porpoise

Harbor porpoises (*Phocoena phocoena*) were proposed for threatened listing on 7 January 1993. This request was applicable to the Gulf of Maine harbor porpoise population which has been depleted in recent years as a result of various Canadian and U.S. gillnet fisheries (i.e., loss via bycatch). No formal action has been taken on this proposed listing (Marine Mammal Commission, 1996).

Harbor porpoises are found in cool temperate and subpolar waters of the Northern Hemisphere. They are typically found in shallow water, most often nearshore, although occasionally travel over deeper offshore waters (Jefferson et al., 1993). During summer, harbor porpoises are concentrated in Canada and the northern Gulf of Maine. During fall and spring, they are widely distributed from Maine to North Carolina (Blaylock et al., 1995). The minimum population estimate was 40,345 individuals (Blaylock et al., 1995).

Harbor porpoises have not been historically recorded off Mayport, but their presence off Norfolk is considered possible. However, given this species' preference for northern coastal waters, it is not likely to occur at either offshore area.

G.2.3 Listed Sea Turtles

A total of five species of endangered or threatened sea turtles may be found at the Mayport or Norfolk areas, based on historical sighting records (**Table G-1**). Endangered species are the hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), and leatherback sea turtles (*Dermochelys coriacea*). The loggerhead sea turtle (*Caretta caretta*) is a threatened species. The green sea turtle (*Chelonia mydas*) is listed as threatened, except for the Florida breeding population which is listed as endangered.

G.2.3.1 Green Sea Turtle

The Atlantic green sea turtle *(Chelonia mydas)* occurs in U.S. Atlantic waters around the U.S. Virgin Islands, Puerto Rico, and continental waters from Texas to Massachusetts. This species may be found in convergence zones in deep water and in shallow, protected waters containing benthic (bottom) feeding grounds. Atlantic green sea turtles commonly feed upon seagrasses and algae, using reefs and rocky outcrops near grass beds for resting areas. Nesting areas are located on high-energy beaches along the Atlantic coast of Florida. The NMFS and USFWS (1991a) identified several large and important nesting areas along the central and southeast coast of Florida, including Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties. Mating occurs in waters off nesting areas. Nesting occurs at night, with females producing clutches of eggs every two years. Hatchlings swim out to sea and enter a pelagic stage in convergence zones.

G.2.3.2 Hawksbill Sea Turtle

Hawksbill sea turtles *(Eretmochelys imbricata)* occur in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. In the western Atlantic, hawksbill turtles are generally found in clear tropical waters of the Caribbean, including the Florida Keys, the Bahamas, and the southwest Gulf of Mexico. Hawksbill turtles are not frequently reported in waters north of Cape Canaveral, Florida. Adults can be found in waters up to 100 m (328 ft) deep. This species feeds on encrusting organisms, particularly sponges. Juvenile hawksbill sea turtles are usually found near shallow coral reefs. Nesting areas for hawksbills in the Atlantic are found in the U.S. Virgin Islands, Puerto Rico, and south Florida. Hatchlings enter a pelagic phase, drifting with *Sargassum* rafts. Juveniles shift to a benthic foraging existence in shallow waters, progressively moving to deep waters as they grow and become capable of deeper dives for sponges. Due to this turtle's endangered status, all nesting areas are critical habitat. Within the continental U.S., nesting beaches are restricted to the southeast coast of Florida (i.e., Volusia through Dade Counties) and the Florida Keys (Monroe County), as noted by Meylan (1992) and the NMFS and USFWS (1993).

G.2.3.3 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle (*Lepidochelys kempii*) is found from the Gulf of Mexico to New England, and occasionally as far north as Nova Scotia. Its distribution along the U.S. southeastern coast is mediated by the Gulf Stream. Adult turtles are usually found in the Gulf of Mexico. Juveniles may move northward along the U.S.

Atlantic coast with the warm waters of the Gulf Stream. Individuals are reported to return southward when waters turn cold. It is believed that this species typically remains shoreward of the 50-m (164-ft) contour line. Kemp's ridley sea turtles forage in shallow water, feeding on crabs, shrimp, gastropods, and fish. Nesting occurs almost entirely in Rancho Nuevo beach, Tamaulipas, Mexico (NMFS and USFWS, 1992). Nesting occurs during the day in April, May, and June, with mature individuals returning on an annual basis (Prichard and Marquez, 1973). Due to the species' endangered status, all nesting areas are considered as critical habitat.

According to the NMFS and USFWS (1992), juvenile and subadult Kemp's ridley sea turtles travel northward along the Atlantic seaboard in spring to feed in the productive, coastal waters between Georgia and New England; these migrants then move southward with the onset of cooler temperatures in late fall and winter. Henwood and Ogren (1987) and Schmid (1995) provided information on length frequency, seasonal occurrence, and long distance migratory patterns of Kemp's ridley sea turtles along the U.S. Atlantic coast.

G.2.3.4 Leatherback Sea Turtle

The leatherback sea turtle *(Dermochelys coriacea)* is a circumglobal species, currently divided into two subspecies (Thompson and Huang, 1993). The subspecies of interest here is *Dermochelys coriacea coriacea* which inhabits waters of the western Atlantic Ocean from Newfoundland to northern Argentina. It is believed that compared to other sea turtles, leatherbacks range the farthest north. This species may be found in shallow waters but is essentially open ocean, or pelagic (Marquez, 1990). Leatherback sea turtles are frequently observed in cool waters of higher latitudes, such as New England and the Canadian Maritime Provinces. Leatherback sea turtles are pelagic feeders (e.g., on coelenterates, particularly jellyfish). This species nests on high energy beaches (i.e., beaches exposed to strong wave action) in Florida as early as late February or March. Incubation lasts 65 days. Very little is known of the pelagic distribution of hatchling and/or juvenile leatherback turtles. Due to the endangered status of the leatherback turtle, all nesting areas are considered critical habitat.

G.2.3.5 Loggerhead Sea Turtle

The loggerhead sea turtle *(Caretta caretta)* is found from South America to New England. This species generally occurs in subtropical waters. Juveniles are pelagic, often drifting in current gyres for several years. It is believed that subadults move to nearshore and into estuarine areas. Adult loggerheads concentrate within middle shelf to shelf edge waters (Schroeder and Thompson, 1987). Adults are found along the continental shelf of the Atlantic and Gulf of Mexico. Loggerheads feed primarily on benthic molluscs and crustaceans. Pelagic stages feed on coelenterates and cephalopods. Mating occurs in late March to early June. Nesting occurs from May to September. Most nesting of the western Atlantic population occurs on beaches of southeast Florida with other nesting areas located in northeast Florida, Georgia, South Carolina, and North Carolina, as well as the Gulf coast of Florida. Incubation lasts about 54 days in Florida and 63 days in Georgia. Hatchlings swim out to 22 to 28 km (12 to 15 nmi) offshore and begin a pelagic existence within *Sargassum* algae rafts. This species is currently listed as threatened. Murphy and Hopkins (1984) estimated that there were 14,150 nesting females utilizing southeast U.S. beaches in 1983, based on

aerial and ground survey data. The NMFS and U.S. Fish and Wildlife Service (USFWS) (1991b) estimated that there are approximately 58,000 nests deposited per year in the southeastern U.S. State agencies in Florida, Georgia, South Carolina, and North Carolina have estimated that about 50,000 to 70,000 nests are deposited annually in this region, according to the loggerhead turtle recovery plan prepared by the NMFS and USFWS (1991b).

G.3 AERIAL SURVEY RESULTS

To supplement historical information on marine mammals and sea turtles and to develop density estimates for impact analysis, monthly aerial surveys were conducted at the Mayport and Norfolk areas from April through September 1995 (Department of the Navy, 1995). Methods are summarized in Appendix B. Parallel survey transects were 1.85 km (1 nmi) apart, with each transect extending 7.4 km (4 nmi) to the east and west of the 152 m (500 ft) depth contour at each area. Standard methods were used, as developed by the NMFS (Blaylock, 1994; Hoggard, 1994; Mullin, 1994). Observers on both sides of the aircraft scanned a swath of sea surface for marine mammals. The total area viewed during each survey was 2,948 km^2 (858 nmi^2) at the Mayport area and 1,470 km^2 (428 nmi^2) at the Norfolk area.

Observed densities from aerial surveys do not take into account submerged individuals or those that may have been on the surface but undetected. Therefore, adjusted densities were developed for each species as explained in Appendix B.

G.3.1 Mayport Area

Only one endangered whale species, the sperm whale, was seen during 1995 aerial surveys off Mayport; two individuals were sighted during May 1995 (**Table G-2**). No endangered baleen whales were seen. Because blue, fin, humpback, and northern right whales generally inhabit northern feeding grounds during most of the survey period, it is not surprising that none were seen near Mayport during the April through September surveys.

At least two listed sea turtle species (loggerhead and leatherback) were seen at the Mayport area during the 1995 surveys. A total of 138 sea turtles were seen, including 128 loggerheads, 6 leatherbacks, and 4 unidentified. Based on all six surveys, observed mean densities of sea turtles were 0.78 individuals/100 km^2, and adjusted mean densities were about 26 individuals/100 km^2. Because there would be no shock testing in April at Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April). For the May-September period, observed mean densities were 0.52 individuals/100 km^2 and adjusted mean densities were about 17 individuals/100 km^2.

As shown in Section 3.2.4 of the DEIS, sea turtle densities at Mayport were highest during the first survey (April 1995) but showed no pattern during the rest of the surveys. About half of all the loggerheads counted during the surveys were seen during April. The high abundance during April may have been due to turtles converging on nearshore areas prior to nesting. Most loggerheads nest between May and September

Table G-2. Abundance and density estimates for endangered and threatened species observed at the Mayport area during April-September 1995 aerial surveys. Because there would be no shock testing during April if the Mayport area is selected, values are given for May-September, with April-September numbers in parentheses.

Species	Observed Abundance[a] (No. of Individuals)	Observed Mean Density[b] (Individuals/ 100 km^2)	Proportion of Population Detected[c]	Adjusted Mean Density[d] (Individuals/ 100 km^2)
MARINE MAMMALS[e]				
Sperm whale (E) (*Physeter macrocephalus*)	2 (2)	0.01 (0.01)	0.09	0.15 (0.13)
SEA TURTLES				
Loggerhead sea turtle (T) (*Caretta caretta*)	67 (128)	0.46 (0.72)	0.030	15.15 (24.12)
Leatherback sea turtle (E) (*Dermochelys coriacea*)	6 (6)	0.04 (0.03)	0.036	1.13 (0.94)
Unidentified hardshell turtle (E or T)	3 (4)	0.02 (0.02)	0.033	0.62 (0.69)

(E) = endangered species. (T) = threatened species. NA = not applicable.

[a] Observed abundance = total individuals observed during five 1995 aerial surveys (May-September); numbers for six surveys (April-September) are given in parentheses.

[b] Observed mean density = mean number of individuals/100 km^2, based on total number of individuals observed ÷ area viewed per survey (2,948 km^2) ÷ 5 surveys × 100 km^2. Numbers for six surveys are given in parentheses.

[c] Proportion of population believed to be detected by the aerial surveys, taking into account submerged individuals and those undetected on the surface (see Appendix B).

[d] Adjusted mean density = observed mean density ÷ proportion detected. Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data; some values may differ slightly from those one could calculate using the tabulated numbers.

[e] Bottlenose dolphins were also seen during the surveys, as explained in Section 3.2.3 of the DEIS. However, only the coastal migratory stock of this species is proposed for listing, and it is assumed that the individuals seen were not from the coastal migratory stock.

on the beaches of southeast Florida, with other nesting areas located in Georgia, South Carolina, and North Carolina, as well as the Gulf coast of Florida.

As shown in Section 3.2.4 of the DEIS, numbers of turtles on a transect ranged from 0 to 5 individuals; within any given survey (and especially during May through September), most transects had zero. Sea turtle abundance and frequency of occurrence was greatest during April and lowest during May. Sea turtles were generally more abundant and widespread in the southern half of the area during May, July, and August, but during the other months, there was no strong north-south pattern.

Due to the high abundance of sea turtles during April at Mayport, it would be difficult to find a test area with no turtles present. Therefore, if Mayport is chosen as the area for shock testing, there would be no testing during April (see Section 2.2.3.1 of the DEIS).

G.3.2 Norfolk Area

Four endangered marine mammal species (fin whale, humpback whale, sei whale, and sperm whale) were observed during April through July surveys at the Norfolk area. Fin whales were the most common baleen whale encountered, with a total of 46 individuals sighted during the survey period (**Table G-3**). The numbers of baleen whales sighted decreased to zero during surveys after July, when it is presumed that these animals had migrated to more northern waters. The only endangered toothed whale species expected to be seen in the Norfolk area, the sperm whale, was sighted on only one occasion during 1995 aerial surveys; four separate individuals were sighted during April 1995.

A total of 48 sea turtles representing at least two listed species were seen during the aerial surveys at the Norfolk area. Of the total, 44 were loggerheads, 1 was a leatherback, and 3 were unidentified. Observed mean densities (all species combined) were 0.54 individuals/100 km^2, and adjusted mean densities were about 18 individuals/100 km^2. As shown in Section 3.2.4 of the DEIS, no sea turtles were seen at the Norfolk area during the first survey (April 1995). Among the other surveys, densities were higher in May and September and lower in June, July, and August. Low densities during summer months may be due to movement of the turtle population inshore for nesting; Dodd (1988) reported nesting of loggerheads occurring along North Carolina beaches between April and late August.

As shown in Section 3.2.4 of the DEIS, numbers of turtles on a transect ranged from 0 to 3 individuals; within any given survey, most transects had zero. Sea turtle abundance and frequency of occurrence was greatest during May and September; during June, July, and August, there were only a few sightings.

G.4 DIRECT AND INDIRECT EFFECTS

G.4.1 Marine Mammals

Two main types of potential direct impacts on marine mammals are discussed in Section 4.0 of the DEIS. First, animals may be killed or injured if they are present near

Table G-3. Abundance and density estimates for endangered and threatened species observed at the Norfolk area during April-September 1995 aerial surveys.

Species	Observed Abundance[a] (No. of Individuals)	Observed Mean Density[b] (Individuals/ 100 km^2)	Proportion of Population Detected[c]	Adjusted Mean Density[d] (Individuals/ 100 km^2)
MARINE MAMMALS[e]				
Fin whale (E) (*Balaenoptera physalus*)	46	0.52	0.18	2.90
Humpback whale (E) (*Megaptera novaeangliae*)	1	0.01	0.18	0.06
Sei whale (E) (*Balaenoptera borealis*)	2	0.02	0.18	0.13
Sei (E)/Bryde's whale (*Balaenoptera borealis/edeni*)	1	0.01	0.18	0.06
Sperm whale (E) (*Physeter macrocephalus*)	4	0.05	0.09	0.50
Unidentified *Balaenoptera* spp. [possibly (E)]	12	0.14	0.18	0.76
Unidentified baleen whale [possibly (E)]	4	0.05	0.18	0.25
SEA TURTLES				
Loggerhead sea turtle (T) (*Caretta caretta*)	44	0.50	0.030	16.63
Leatherback sea turtle (E) (*Dermochelys coriacea*)	1	0.01	0.036	0.31
Unidentified hardshell turtle (E or T)	3	0.03	0.033	1.03

(E) = endangered species. (T) = threatened species. NA = not applicable.

[a] Observed abundance = total individuals observed during six 1995 aerial surveys.
[b] Observed mean density = mean number of individuals/100 km^2, based on total number of individuals observed ÷ area viewed per survey (1,470 km^2) ÷ 6 surveys × 100 km^2.
[c] Proportion of population believed to be detected by the aerial surveys, taking into account submerged individuals and those undetected on the surface (see Appendix B).
[d] Adjusted mean density = observed mean density ÷ proportion detected. Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data; some values may differ slightly from those one could calculate using the tabulated numbers.
[e] Bottlenose dolphins were also seen during the surveys, as explained in Section 3.2.3 of the DEIS. However, only the coastal migratory stock of this species is proposed for listing, and it is assumed that the individuals seen were not from the coastal migratory stock.

the detonation point and not detected during pre-test monitoring. Second, animals at greater distances may experience temporary acoustic discomfort. Behavioral responses and possible indirect impacts to marine mammals are also discussed. Appendices D and E present technical calculations concerning potential mortality, injury, and acoustic discomfort of marine mammals.

In addition to these main effects, there are several minor issues that do not require detailed analysis. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3). Minor increases in vessel and air traffic are not a major concern from the standpoint of marine mammal harassment because of built-in mitigation measures (use of shipboard observers; limited transit speed; and flights at approved altitudes).

The proposed action includes mitigation that would minimize risk to marine mammals (see Section 5.0). The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If post-detonation monitoring showed that marine mammals or turtles were killed or injured as a result of a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

The safety range radius of 3.79 km (2.05 nmi) was calculated using information on eardrum rupture, which is the most conservative measure of non-lethal injury discussed in Appendix D. The maximum predicted horizontal distance for a 10% probability of eardrum rupture for a marine mammal is 3.79 km (2.05 nmi). Aerial and acoustic monitoring would extend beyond the safety range to ensure that no marine mammal could enter the safety range prior to detonation (see Section 5.0). The safety range radius is more than twice the maximum range for lethality.

G.4.1.1 Overview of Impact Analysis

The actual numbers of marine mammals that may be killed, injured, or experience acoustic discomfort as a result of SEAWOLF shock testing cannot be known in advance. Previous experience during the shock trial of the USS JOHN PAUL JONES, which involved detonation of two 4,536 kg (10,000 lb) charges, showed there were no marine mammal deaths or injuries (Naval Air Warfare Center, 1994) despite observed marine mammal population densities that were about 3 times greater than at the Norfolk area and about 25 times higher than at the Mayport area (Department of the Navy, 1993). Similar mitigation methods are proposed for the SEAWOLF shock testing (see Section 5.0). In addition, based on the patchy distribution of marine mammals at the Mayport and Norfolk areas as shown in Figures 3-3 and 3-4 of the DEIS, the Navy expects to be able to select a specific test site with few, if any, marine mammals present.

However, it is necessary to estimate numbers of potentially affected animals to make a determination as to whether the proposed action would jeopardize the continued existence of threatened and endangered species. This analysis deliberately

overestimates numbers of affected animals in order to provide an upper bound on potential impacts. Because the same assumptions and methods are used for both Mayport and Norfolk, the analysis is appropriate for comparing the alternative areas.

The number of listed marine mammals potentially killed, injured, or experiencing acoustic discomfort as a result of the proposed detonations was estimated using a series of steps and assumptions:

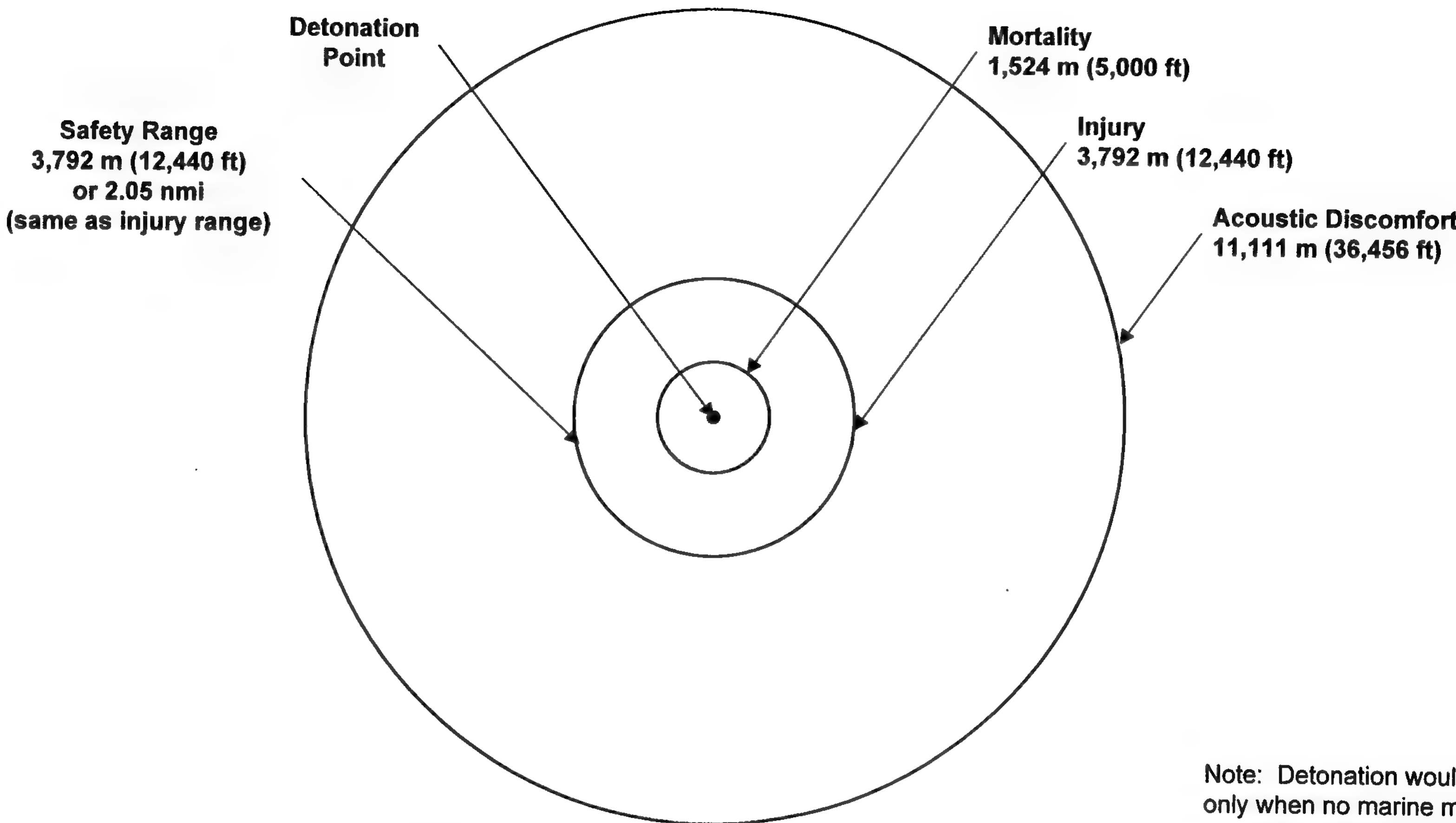
1. Maximum ranges for mortality, injury, and acoustic discomfort were defined using criteria developed in Appendices D and E, as explained later in this section. The acoustic discomfort criterion is based on data from humans, and the mortality and injury criteria are based on tests conducted with other terrestrial mammals. The models developed to apply these data to marine mammals are believed to be "conservative;" that is, they include a margin of safety to avoid underestimating the effect range.

2. These maximum ranges were used to define concentric circles around the detonation point (**Figure G-4**), and to calculate the area within each circle. The area of the injury range was corrected by subtracting the area of the mortality range to avoid double-counting mortality and injury; i.e., if an animal were killed, it should not also be counted as injured. Similarly, the uncorrected area of the injury range was subtracted from the acoustic discomfort range. Resulting areas were as follows:
   - Mortality range: 7.30 km^2 (2.13 nmi^2)
   - Injury range: 37.87 km^2 (11.03 nmi^2)
   - Acoustic discomfort range: 342.70 km^2 (99.78 nmi^2)

3. Mean densities of each species were multiplied by the area of the mortality, injury, and acoustic discomfort ranges to estimate the number of mammals affected "without mitigation" for a single detonation. Mean densities were taken from Section 3.2.3 and are based on 1995 aerial survey counts adjusted for submerged and undetected individuals.

4. Mitigation effectiveness was estimated for each species, taking into account the probability of detection by aerial and surface observers and passive acoustic monitoring (see Appendix B). For mortality and injury, the "without mitigation" numbers for each species were then multiplied by (1 minus mitigation effectiveness), which is the probability of not detecting that species during pre-detonation monitoring. The resulting values are the expected number of undetected animals of each species within the mortality and injury ranges.

5. For acoustic discomfort, the "with mitigation" numbers were assumed to be equal to the "without mitigation" numbers, because only animals outside the safety range would be affected.



Note: Detonation would occur only when no marine mammals, turtles, seabird flocks, or large schools of fish are detected within the safety range.

Figure G-4. Maximum horizontal ranges for mortality, injury, and acoustic discomfort in relation to the safety range for mitigation efforts.

6. The mortality, injury, and acoustic discomfort estimates for a single detonation were multiplied by five to account for the five detonations that would occur during SEAWOLF shock testing. Species historically present at or near each area but not seen during 1995 aerial surveys were each assigned a value of one individual for acoustic discomfort. This value is similar to those calculated for the least abundant species observed during 1995 aerial surveys. The results were totalled and then rounded up to the nearest whole number.

There are several key assumptions. First, it was assumed that marine mammal densities during shock testing would be similar to those during 1995 aerial surveys. Although this may or may not hold true, the 1995 observations are the best quantitative data available for both areas. Also, other species with historical sightings from the Mayport or Norfolk areas were taken into account by assuming one individual of each of these species would experience acoustic discomfort. Second, it was assumed that the mean density for a whole area (Mayport or Norfolk) can be used to predict the expected number of animals that would occur within a small test site. This assumption overestimates impacts, because the abundance of marine mammals is patchy within both areas (see Figures 3-3 and 3-4 in the DEIS) and the Navy proposes to select an operationally suitable test site with the lowest possible density of marine mammals and turtles (i.e., much lower than the mean density for the area as a whole). Finally, the estimates of detectability (mitigation effectiveness) for each species are assumed to be accurate. These numbers were developed through an orderly and logical process that included consultation with and review by marine mammal experts (see Appendix B).

Results of the calculations are presented in **Tables G-4 and G-5** for Mayport and Norfolk, respectively.

G.4.1.2 Mortality and Injury

Marine mammals can be killed or injured by underwater explosions due to the response of air cavities, such as the lungs and bubbles in the intestines, to the shock wave (Yelverton et al., 1973; Hill, 1978; Goertner, 1982). Effects are likely to be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (**Figure G-5**). This is a region of near total physical trauma within which no animals would be expected to survive. Based on calculations in Appendix D, the maximum horizontal extent of the cavitation region is estimated at 494 m (1,620 ft) for the proposed detonations. This region would extend from the surface to a maximum depth of about 24 m (80 ft).

A second measure of possible mortality (and the one which is used here) is the maximum range for the onset of extensive lung hemorrhage. Extensive lung hemorrhage is considered debilitating and potentially fatal; suffocation caused by lung hemorrhage is likely to be the major cause of marine mammal death from underwater shock waves, based on experiments with terrestrial mammals (Hill, 1978). Appendix D presents calculations which estimate the maximum range for the onset of extensive lung hemorrhage to marine mammals. The range varies depending on mammal weight, with the smallest mammals having the greatest range. The maximum range predicted for a small marine mammal is 1,524 m (5,000 ft) from the detonation point (**Figure G-6**). This value is more conservative than the estimated lethal range of 70 to 800 m (230 to

Table G-4. Estimates of potential mortality, injury, and acoustic discomfort for listed marine mammals potentially occurring at the Mayport area, with and without mitigation. Shock testing would only be conducted "with mitigation," including no testing in April at Mayport. Numbers are given to two decimal places to indicate the relative risk to various species. Species historically present in the region but not seen at Mayport during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
* Blue whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Fin whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Humpback whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Northern right whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Sei whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
Sperm whale (E)	0.01	0.06	0.52	0.81	<0.01	0.01	0.52	0.01	0.05	2.58

(E) = endangered species. NA = not applicable. * = species historically present in the region but not seen at the Mayport area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities for May through September at Mayport, scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).
b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).
c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

Table G-5. Estimates of potential mortality, injury, and acoustic discomfort of listed marine mammals potentially occurring at the Norfolk area, with and without mitigation. Shock testing would only be conducted "with mitigation." Numbers are given to two decimal places to indicate the relative risk to various species. Species historically present in the region but not seen at Norfolk during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[c] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
* Blue whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
Fin whale (E)	0.21	1.10	9.93	0.89	0.02	0.12	9.93	0.12	0.60	49.65
Humpback whale (E)	0.01	0.02	0.22	0.89	<0.01	<0.01	0.22	<0.01	0.01	1.08
* Northern right whale (E)	0	0	0.20	NA	0	0	0.20	0	0	1
Sei whale (E)	0.01	0.05	0.43	0.89	<0.01	0.01	0.43	0.01	0.03	2.16
Sei (E) or Bryde's whale	0.01	0.02	0.22	0.89	<0.01	<0.01	0.22	<0.01	0.01	1.08
Sperm whale (E)	0.04	0.19	1.73	0.81	0.01	0.04	1.73	0.04	0.18	8.63
Unidentified *Balaenoptera* sp. [possibly (E)]	0.05	0.29	2.59	0.89	0.01	0.03	2.59	0.03	0.16	12.95
Unidentified baleen whale [possibly (E)]	0.02	0.09	0.86	0.89	<0.01	0.01	0.86	0.01	0.05	4.32

(E) = endangered species. NA = not applicable. * = species historically present in the region but not seen at the Norfolk area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities for April through September at Norfolk, scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).

b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).

c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

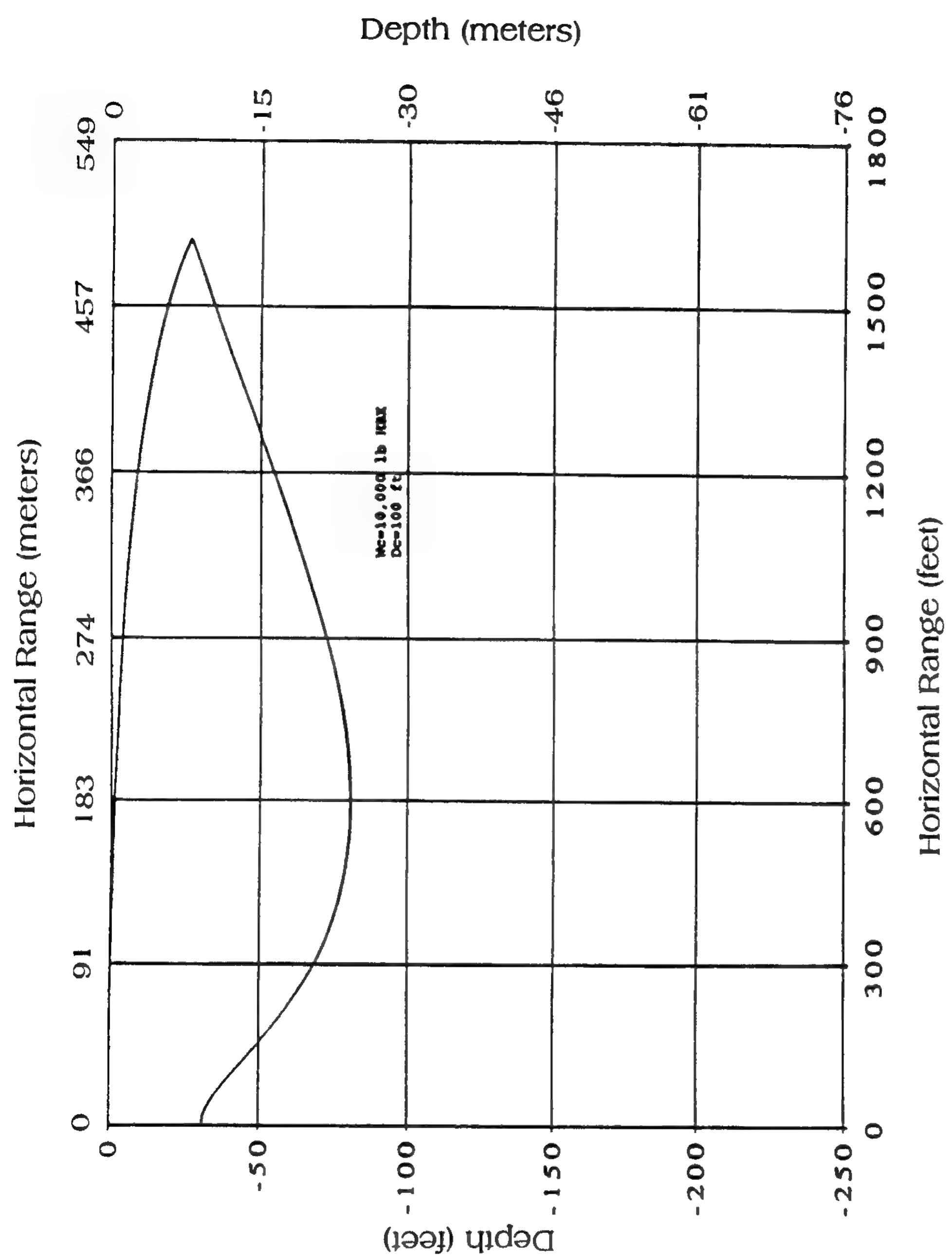


Figure G-5. Bulk cavitation region for a 4,536-kg (10,000-lb) charge (From: Appendix D).

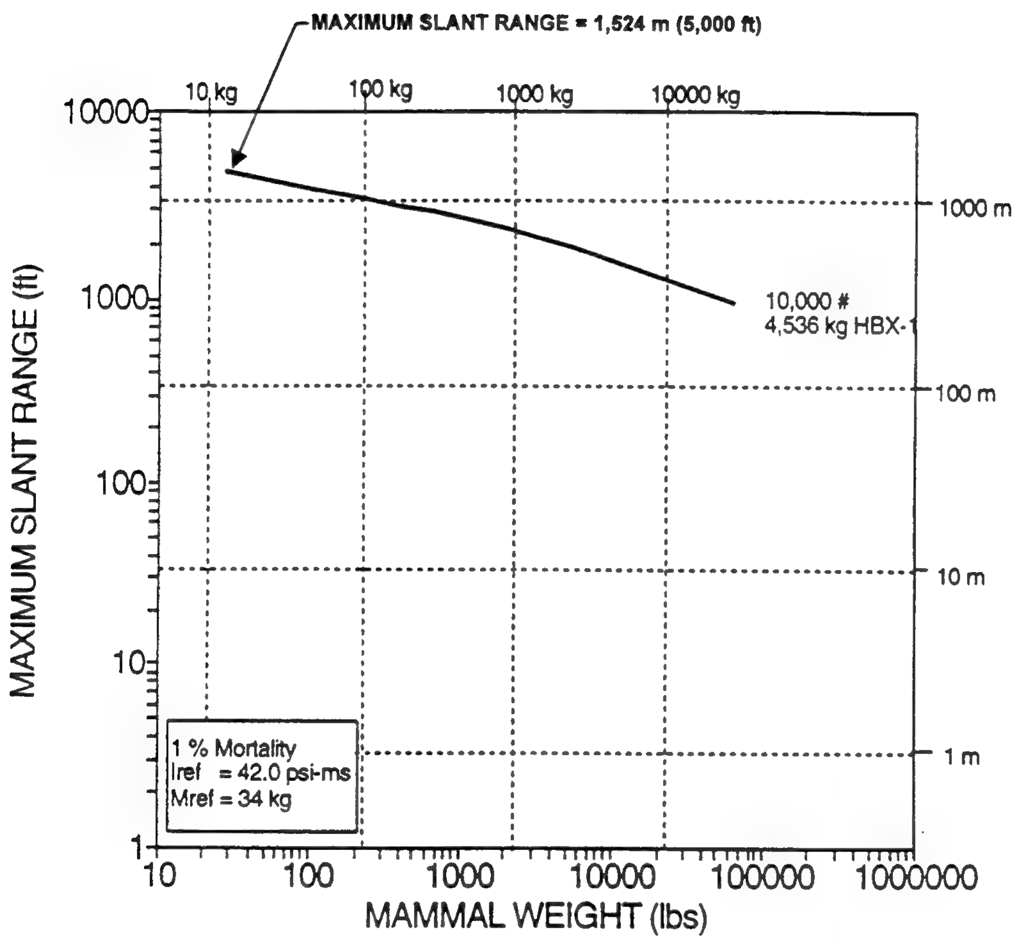


Figure G-6. Maximum calculated ranges for 1% mortality (onset of extensive lung hemorrhage) as a function of mammal weight for a 4,536-kg (10,000-lb) charge (From: Appendix D).

2,625 ft) calculated by Ketten (1994) for the same size charge. *For purposes of impact analysis, it was assumed that 100% of the marine mammals within 1,524 m (5,000 ft) of the detonation point would be killed, even though the probability of mortality from extensive lung hemorrhage is estimated to be only 1% at the outer edge of this range.*

Two measures of non-lethal injury are also discussed in Appendix D: slight lung hemorrhage and eardrum rupture. These are injuries from which animals would be expected to recover on their own. The maximum range for slight lung hemorrhage is 1,850 m (6,069 ft). The maximum range for 10% probability of eardrum rupture varies from 2,408 m (7,900 ft) to 3,792 m (12,440 ft) depending on mammal depth in the water column. The latter value is for a mammal at the bottom (**Figure G-7**). The 10% eardrum rupture range at the bottom was used as the maximum range for non-lethal injury. *For purposes of impact analysis, it was assumed that 100% of marine mammals between 1,524 m (5,000 ft) and 3,792 m (12,440 ft) from the detonation point would be injured, even though the probability of eardrum rupture at the outer edge of this range is only 10% (and less in near-surface waters).*

It is recognized that some percentage of the animals with eardrum rupture or slight lung hemorrhage could eventually die from their injuries. However, this is taken into account by the mortality criterion discussed above (onset of extensive lung hemorrhage), which deliberately overestimates mortality by assuming 100% of animals within a radius of 1,524 m (5,000 ft) would be killed. At this radius, the probability of eardrum rupture is 50% or less in the upper water column and 50% to 95% in deeper water (see Figure 11 in Appendix D); i.e., all animals within this radius are assumed to be killed even though some animals might not even have eardrum rupture.

Table G-4 summarizes the mortality and injury calculations for the Mayport area. The only endangered marine mammal species potentially killed or injured at Mayport is the sperm whale. The estimated numbers are 0.01 or less per detonation for both mortality and injury; totals for five detonations are 0.01 mortalities and 0.05 injuries. Therefore, it is highly unlikely that any sperm whales would be killed or injured by the five detonations. Sperm whales produce distinctive clicked vocalizations (Jefferson et al., 1993) and are very likely to be detected (if present) using the passive acoustic monitoring system described in Section 5.0 (Tyack, 1996). The other endangered marine mammals (blue, fin, humpback, sei, and northern right whales) are baleen whales which generally inhabit northern feeding grounds during the period proposed for shock testing (see Appendix B) and which were never observed off Mayport during the 1995 aerial census efforts. Therefore, it is assumed none would be killed or injured by the proposed action.

Table G-5 summarizes the mortality and injury calculations for the Norfolk area. In contrast to Mayport, several endangered whale species could be affected at the Norfolk area. The highest numbers are for fin whale, which was the most abundant baleen whale at the area during 1995 aerial surveys. It is unlikely that a fin whale would be killed (0.12 individuals), but more likely that one would be injured (0.60 individuals). For the humpback, sei, and sperm whales, the mortality values per detonation are 0.01 individuals or fewer, indicating it is very unlikely that individuals of these species would be killed. Two other endangered species, the blue whale and the northern right whale, generally inhabit northern feeding grounds during the period proposed for shock testing and were never observed off Norfolk during the 1995 aerial census efforts;

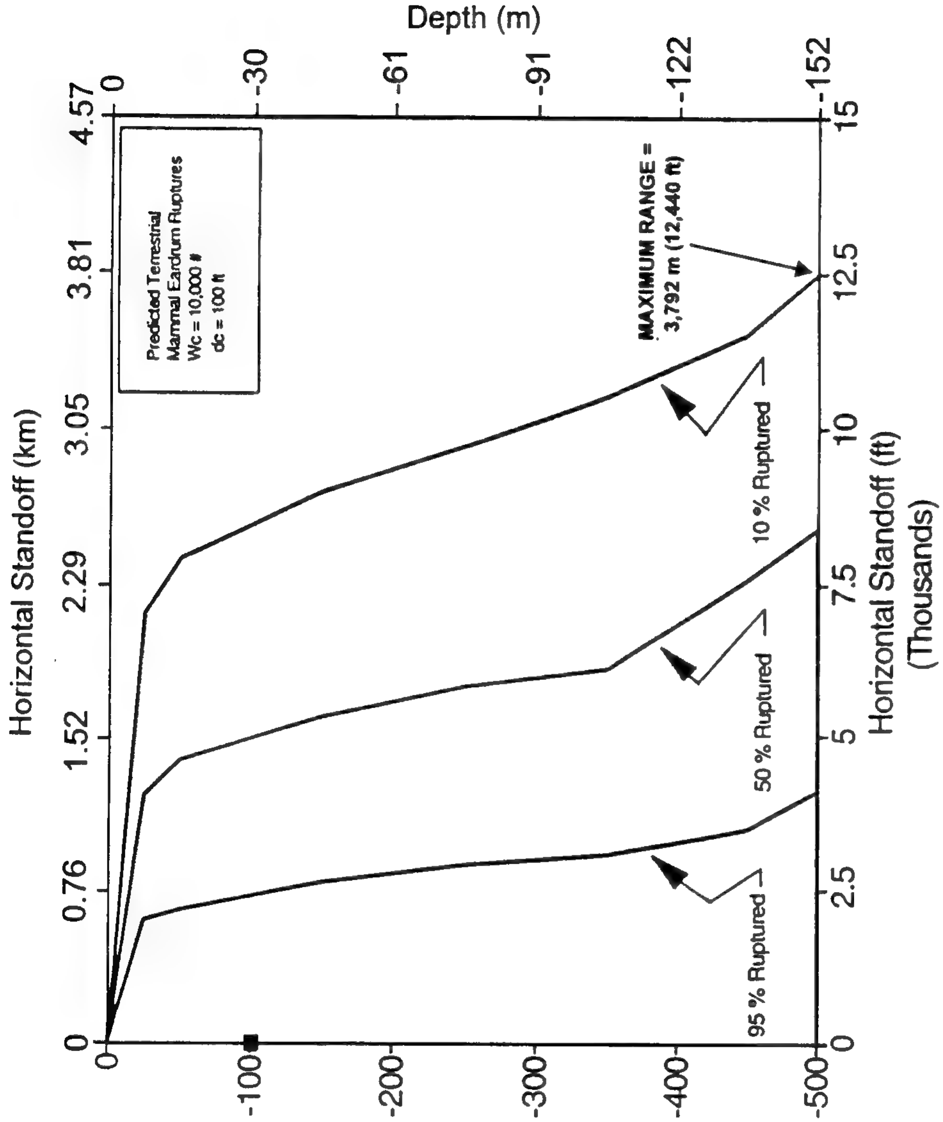


Figure G-7. Eardrum rupture injury contours for a 4,536-kg (10,000-lb) charge (From: Appendix D).

therefore, they are assumed to have no mortalities or injuries. In general, potential risk to endangered whale species would be lowest if testing occurred during July, August, or September; during 1995 aerial surveys, only one individual of an endangered species (fin whale) was seen during those months.

Both tables show the mitigation effectiveness for individual species and for total marine mammals. Overall mitigation effectiveness for mortality and injury would be about 93% for both Mayport and Norfolk.

G.4.1.3 Acoustic Discomfort

An underwater explosion produces pressure pulses that have the potential for damaging the hearing of marine mammals (Ketten, 1994). Depending on an animal's distance from the detonation point, it could experience a temporary or permanent shift in the threshold of hearing (the quietest sound that the animal can hear), which could affect the animal's ability to hear calls, echolocation sounds, and other ambient sounds. Animals close to the detonation point could experience permanent threshold shift (PTS), which is permanent hearing loss. Animals at greater distances could experience temporary threshold shift (TTS). At still greater distances, animals could experience acoustic discomfort, which would be a momentary disturbance with no effect on hearing thresholds.

According to Richardson et al. (1995), the distances at which marine mammal auditory systems might be at risk for PTS from a single explosive pulse can be estimated based on extrapolations from human damage risk criteria. Based on the data presented by Richardson et al. (1995; p. 376), PTS might be expected to occur within distances of about 3.1 km (1.7 nmi) from the detonation point for a 4,536 kg (10,000 lb) charge. Ketten (1994) hypothesized a smaller PTS zone extending about 0.9 km (0.5 nmi) from the detonation point, within which >50% of animals would have some permanent hearing loss; and a PTS/TTS transitional zone extending from about 0.9 to 5 km (0.5 to 2.7 nmi) from the detonation point, within which most animals would have some temporary hearing loss but some permanent auditory damage would also be found. Based on these calculations and the fact that shock wave intensity decays exponentially with distance, it is reasonable to assume that PTS is unlikely to occur beyond the eardrum rupture range defined previously (3.79 km or 2.05 nmi). Therefore, PTS is not discussed further.

Harassment, as defined in the 1994 amendments to the Marine Mammal Protection Act of 1972, is "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild;" (Level A harassment) or "(ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" (Level B harassment). Level A harassment means injury, which has been discussed above. The NMFS has not defined a threshold for Level B harassment, but has cited TTS as an example (60 Federal Register at 28383, 31 May 1995). As explained below, there are currently insufficient data to develop a TTS criterion for marine mammals. Therefore, a criterion for "acoustic discomfort" has been used in this impact analysis. The number of marine mammals potentially experiencing acoustic discomfort is an overestimate of Level B harassment. Acoustic discomfort would be a momentary disturbance that would not cause TTS and would not be expected to cause disruption of behavioral patterns such as migration,

breathing, nursing, breeding, feeding, or sheltering. In addition, because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would experience this momentary discomfort more than once.

To define the range (distance) of possible effects on marine mammal hearing, an interim criterion for acoustic discomfort was developed based on sound levels that would not cause TTS (Appendix E). The most meaningful criterion would be one based on measurements of TTS resulting from exposure of marine mammals to underwater noise. Although hearing thresholds for odontocetes and pinnipeds exposed to pure tones have been measured, there are no available TTS data for any marine mammals (Richardson et al., 1995). Therefore, other methods were used to develop a criterion for acoustic discomfort. Data obtained from humans immersed in water and exposed to brief pure tones were used, assisted by human in-air data, to construct an underwater hearing-safety limit for marine mammals. Evidence that indicates how safe this limit is has been provided in Appendix E. The acoustic discomfort criterion was then applied to define an acoustic discomfort range for the proposed detonations. Site-specific hydrographic data from the Mayport and Norfolk areas were used to calculate the acoustic discomfort range (Appendix E).

Based on the analysis in Appendix E, the maximum range for acoustic discomfort at the Mayport and Norfolk areas is 11.11 km (6 nmi). Expected numbers of marine mammals within this radius were calculated using adjusted mean densities from Section 3.2.3. Because only individuals outside the 3.79 km (2.05 nmi) safety range would be affected, the "with mitigation" and "without mitigation" numbers would be the same.

It is considered impractical to attempt to mitigate for possible acoustic discomfort, which is a momentary disturbance. Increasing the safety range from 3.79 km (2.05 nmi) to 11.11 km (6 nmi) would increase the area by more than 850%, creating logistical and safety problems and reducing the effectiveness of mitigation for mortality and injury.

Because of the larger area of the acoustic discomfort range, more individuals and more species could be affected. Therefore, species historically present at or near each area but not seen during 1995 aerial surveys were taken into account in these calculations. Each species was assigned a value of 0.2 individuals per detonation, for a total of 1 individual per 5 detonations. This value is similar to the values calculated for the least abundant species observed during 1995 aerial surveys. The results were totalled and then rounded up to the nearest whole number.

Tables G-4 and G-5 summarize the results of the acoustic discomfort calculations for the Mayport and Norfolk areas. If the Mayport area is selected, the sperm whale is estimated to have about 3 individuals affected, and the blue, fin, humpback, northern right, and sei whales are each assumed to have a single affected individual (even though these species are very unlikely to be present). If the Norfolk area is selected, the total number of listed individuals potentially affected is much higher, about 82 individuals. The total includes about 50 fin whales, 9 sperm whales, 2 to 3 sei whales, and 17 unidentified baleen whales. Blue whales and northern right whales are assumed

to have 1 individual each affected (even though these species are very unlikely to be present).

G.4.1.4 Behavioral Responses

Research on behavioral reactions of marine mammals to impulsive noise has been summarized by Richardson et al. (1995). Although some controlled experiments have been conducted, most of the available information is anecdotal, with no data on the sound levels at the source and the receiver. Behavioral responses to sounds produced by underwater explosions and airgun arrays can include avoidance, altered patterns of surfacing and respiration, and interruptions in calling. Richardson et al. (1995) concluded that "some baleen whales show no strong behavioral reaction to noise pulses from distant explosions. They also show considerable tolerance of similar noise pulses from nonexplosive seismic exploration. However, strong seismic pulses elicit active avoidance, suggesting that explosives may sometimes do so as well."

There is not as much information available on the behavioral responses of toothed whales and dolphins (Richardson et al., 1995). Avoidance and/or interruptions in calling have been documented in sperm whales at great distances from airgun arrays (Bowles et al., 1994; Mate et al., 1994). Small explosive charges have often been used, with mixed success, to influence movement of dolphins (e.g., "seal bombs" used during purse-seining for yellowfin tuna).

It is reasonable to conclude that sounds produced by each detonation during SEAWOLF shock testing could startle marine mammals or result in avoidance or other subtle behavioral changes at distances beyond the acoustic discomfort range discussed above. However, animals outside this range would not experience any hearing damage or even brief acoustic discomfort. In addition, each detonation would be a single momentary disturbance, and because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would hear more than one detonation. Therefore, no significant impact on movements, migration patterns, breathing, nursing, breeding, feeding, or other normal behaviors would be expected.

G.4.1.5 Impacts on Critical Habitat

Based on information received from the NMFS (Appendix C), critical habitat for one endangered species, the northern right whale, exists near Mayport. No critical habitat for other endangered or threatened marine mammals or sea turtles exists within or near the Mayport or Norfolk area.

The right whale critical habitat is located along the northeast Florida coast well inshore of the Mayport area (see **Figure G-2**). The distance between the Mayport area and the right whale critical habitat ranges from 76 to 115 km (41 to 62 nmi), greatly exceeding the mortality and injury ranges for marine mammals (3.79 km or 2.05 nmi) and swimbladder fish (1.85 km or 1 nmi). Therefore, the proposed action would not result in any destruction or adverse modification of the right whale critical habitat. More importantly, because of their seasonal migrations, right whales are not expected to be present within the Mayport critical habitat area during the May through September period proposed for shock testing, as discussed above (Section G.2.1.4).

G.4.1.6 Other Indirect Impacts

An indirect way in which listed marine mammals could be affected is through death and injury to prey species. However, significant impacts are unlikely because (1) the Mayport and Norfolk areas are not known marine mammal feeding grounds, and (2) only a small area would be affected and prey populations would be rapidly replenished.

Feeding habits of listed marine mammals have been summarized in the species descriptions provided in Section G.2. Sperm whales feed primarily on squid, whereas baleen whales generally feed on planktonic crustaceans and small fish.

Pelagic fish and invertebrates within the cavitation region at the time of detonation are expected to be killed or injured. However, it is unlikely that prey availability would be altered for more than a few hours; as a result of turbulent mixing, fish and invertebrate nekton (e.g., squid) from surrounding areas would quickly repopulate the small area affected. Plankton populations would be replenished through turbulent mixing with adjacent waters and population growth of each plankton species. Given that test site selection would be based on the low abundance of marine mammals, including both toothed and baleen whales, and given that the Mayport and Norfolk areas do not represent recognized feeding grounds for marine mammals, the potential for significant indirect effects is very low.

G.4.1.7 Summary and Conclusions

Potential impacts on listed marine mammals have been analyzed in detail in the preceding discussion. Possible direct impacts include mortality, injury, acoustic discomfort, and behavioral responses. Possible indirect impacts to marine mammals due to explosion by-products and impacts on prey species have also been discussed but are considered not significant.

The numbers presented above are based on conservative assumptions which overestimate impacts at both Mayport and Norfolk. As described in Section 5.0, the Navy proposes to select a specific test site with few, if any, marine mammals present. The proposed mitigation methods for SEAWOLF shock testing were used successfully during the shock trial of the USS JOHN PAUL JONES, resulting in no deaths or injuries to marine mammals (Naval Air Warfare Center, 1994). Detection of even one marine mammal within the safety range would result in postponement of detonation; therefore, the presence of marine mammals would most likely result in testing delays rather than impacts on these animals.

Listed Species, Mayport Area

If the Mayport area is selected, it is very unlikely that any endangered marine mammals would be killed or injured. Sperm whales could be present, but in very low densities, and these animals are very likely to be detected by aerial and surface observers and/or passive acoustic monitoring (see Section 5.0). The estimated numbers are 0.01 or less per detonation for both mortality and injury; totals for five detonations are 0.01 mortalities and 0.05 injuries. As used in the impact analysis, the term "injury" refers to non-lethal injury from which an animal would be expected to recover on its own.

Therefore, it is highly unlikely that a sperm whale would be killed by the five detonations. Even if a sperm whale were accidentally killed at the Mayport area, the loss of a single individual would not be likely to jeopardize the continued existence of the species. The sperm whales which occur along the eastern U.S. represent only a fraction of the total stock, and their minimum population estimate is 226 individuals (Blaylock et al., 1995).

Northern right whales and other endangered baleen whales are very unlikely to occur at the Mayport area during the time period proposed for shock testing (May through September) and are assumed to have no mortalities or injuries. During 1995 aerial surveys over the Mayport area, no baleen whales were identified during the six month period from April through September (Department of the Navy, 1995).

In terms of acoustic discomfort, the sperm whale is estimated to have about 3 individuals affected, and the blue, fin, humpback, northern right, and sei whales are each assumed to have a single affected individual (even though these species are very unlikely to be present). Acoustic discomfort would be a momentary disturbance that would not cause TTS and would not be expected to cause disruption of behavioral patterns such as migration, breathing, nursing, breeding, feeding, or sheltering. In addition, because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would experience this momentary discomfort more than once.

Critical habitat for one endangered species, the northern right whale, exists near Mayport. However, because of the distance from the offshore shock testing area to the right whale critical habitat (76 to 115 km, or 41 to 62 nmi), the proposed action would not result in destruction or adverse modification of the right whale critical habitat. More importantly, because of their seasonal migrations, right whales are not expected to be present within the Mayport critical habitat area after late March. During the May through September period proposed for shock testing, most right whales are found feeding north of Cape Cod (Kraus et al., 1993). This finding is further supported by the aerial surveys conducted over the Mayport area; no northern right whales were identified during the six month period from April through September (Department of the Navy, 1995).

In conclusion, if the Mayport area is selected, the proposed action is not likely to jeopardize the continued existence of any endangered or threatened marine mammal species or result in destruction or adverse modification of their critical habitat.

Listed Species, Norfolk Area

If the Norfolk area is selected, the endangered fin whale is abundant enough to possibly have a single mortality or injury; however, if present, these animals are very likely to be detected by aerial or shipboard observers. Endangered humpback, sei, and sperm whales could also be present at Norfolk, but in very low densities; therefore, no mortalities or injuries are expected. Other endangered marine mammals (blue whale, northern right whale) are very unlikely to occur at the Norfolk area during the time period proposed for shock testing (April through September).

Although the accidental death or injury of a fin whale is possible if the Norfolk area is selected, the loss or injury of a single individual would not be likely to jeopardize the continued existence of the species. The minimum population estimate for this species

off the eastern U.S. is 1,704 individuals, based on a 1991-92 shipboard survey (Blaylock et al., 1995).

In terms of acoustic discomfort, the total number of listed individuals potentially affected at Norfolk is about 82 individuals. The total includes about 50 fin whales, 9 sperm whales, 2 to 3 sei whales, and 17 unidentified baleen whales. Blue whales and northern right whales are assumed to have 1 individual each affected (even though these species are very unlikely to be present). Acoustic discomfort would be a momentary disturbance that would not cause TTS and would not be expected to cause disruption of behavioral patterns such as migration, breathing, nursing, breeding, feeding, or sheltering. In addition, because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would experience this momentary discomfort more than once.

In conclusion, if the Norfolk area is selected, the proposed action is not likely to jeopardize the continued existence of any endangered or threatened marine mammal species or result in destruction or adverse modification of their critical habitat. No critical habitat for endangered or threatened marine mammals exists within or near the Norfolk area.

Candidate Species, Mayport or Norfolk Area

As noted in Section G.2.2, two additional marine mammal species, the bottlenose dolphin and the harbor porpoise, have been proposed for listing as threatened. Although bottlenose dolphins are likely to occur at either the Mayport or Norfolk area, the coastal migratory stock proposed for threatened status occurs predominantly in shallow, nearshore waters and is not likely to occur at either offshore area. Harbor porpoises have not been historically recorded off Mayport, but their presence off Norfolk is considered possible. However, given this species' preference for northern coastal waters, it is not likely to occur at either offshore area.

The impact analysis in Section 4.0 of the DEIS estimates no mortalities or injuries and one individual experiencing acoustic discomfort for each species considered unlikely to occur at the Mayport or Norfolk areas. Based on this analysis, no mortalities or injuries of the two candidate species are expected to occur. Therefore, the proposed action is not likely to jeopardize the continued existence of either candidate marine mammal species. No critical habitat has been designated for either species.

G.4.2 Sea Turtles

Two main types of potential direct impacts on sea turtles are discussed in the DEIS. First, animals may be killed or injured if they are present near the detonation point and not detected during pre-test monitoring. Second, animals at greater distances may be disturbed by the physical and acoustic signatures of the explosions. Possible indirect impacts to sea turtles are also discussed.

In addition to these main effects, there are several minor issues that do not require detailed analysis. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3 in the DEIS). Minor

increases in vessel and air traffic are not a major concern from the standpoint of sea turtle harassment because of built-in mitigation measures (use of shipboard observers; limited transit speed; flights at approved altitudes).

The proposed action includes mitigation that would minimize risk to sea turtles (see Section 5.0 in the DEIS). The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If small turtles were found associated with floating *Sargassum* within the safety range, they would be removed and temporarily held in a sun-protected area on the deck of the MART vessel until after the detonation (see Section 5.0 in the DEIS). If post-detonation monitoring showed that marine mammals or sea turtles were killed or injured as a result of a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

Mitigation measures also include a schedule shift to avoid high turtle densities in April at Mayport. Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September 1997. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995, as explained in Section 3.2.4 of the DEIS. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

G.4.2.1 Mortality and Injury

Field observations have shown that sea turtles can be killed or injured by underwater explosions (O'Keeffe and Young, 1984; Klima et al., 1988). Effects are likely to be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (**Figure G-5**). This is a region of near total physical trauma within which no animals would be expected to survive. Beyond the bulk cavitation region, animals could still receive serious or minor injuries depending on distance from the detonation point.

The concept of a "safety range" has been discussed above under Marine Mammals. The same safety range of 3.79 km (2.05 nmi) would be used for both sea turtles and marine mammals. Detonation would not occur until there are no sea turtles or marine mammals detected within the safety range.

Although the safety range was calculated based on estimated maximum ranges for marine mammal mortality and injury (Appendix D), it is more than sufficient to protect sea turtles as well. The safety range is nearly three times greater than the non-injury range of 1.31 km (0.71 nmi) predicted using the O'Keeffe and Young (1984)

equation for sea turtles. It is similar to the predicted safe range of 3.68 km (2 nmi) calculated using an equation developed by Young (1991).

With the safety range in place, sea turtles may be killed or injured only if they are not detected during pre-test monitoring. To estimate how many sea turtles could be killed or injured, the same methods and assumptions were used as described above under Marine Mammals. There is comparatively little experimental or theoretical data upon which to base mortality and injury ranges for sea turtles (O'Keeffe and Young, 1984; Young, 1991). Therefore, the corresponding ranges for marine mammals were used. These ranges were developed based on experiments with mammals (see Appendix D), but it is reasonable to assume that sea turtle lungs and other gas-containing organs would be similarly affected by shock waves (O'Keeffe and Young, 1984). The mortality range of 1,524 m (5,000 ft) and the injury range of 3,792 m (12,440 ft) exceed the distances at which sea turtle mortality and injury would be predicted based on the few observations cited by O'Keeffe and Young (1984) and Klima et al. (1988).

Tables G-6 and G-7 summarize mortality and injury calculations for sea turtles at the Mayport and Norfolk areas. For five detonations "with mitigation," the estimated mortality is about 6 individuals at both Mayport and Norfolk. Predicted numbers of injured turtles for five detonations are 30 at Mayport and 32 at Norfolk. Loggerheads make up over 90% of the population at both areas and are the species most likely to be killed or injured. The three other listed sea turtle species (green, hawksbill, and Kemp's ridley) are primarily inshore species which were not seen at either area during 1995 aerial surveys. Therefore, no mortalities or injuries of these species are expected.

Average mitigation effectiveness for mortality and injury is about 8% for both Mayport and Norfolk. Mitigation is not very effective for sea turtles because they are small, stay submerged for extended periods, do not make visual displays (like dolphins leaping or whales blowing) and do not make sounds. Mitigation effectiveness for juvenile turtles is assumed to be equal to that for adult turtles; although juveniles are smaller, they are often associated with *Sargassum* mats, which would be spotted by aerial observers and investigated by scientists from the MART vessel (see Section 5.0 in the DEIS).

G.4.2.2 Acoustic Discomfort

An underwater explosion produces pressure pulses that have the potential for damaging the hearing of sea turtles. Results of such an exposure could lead to TTS, which is a temporary increase in the threshold of hearing (the quietest sound that the animal can hear). Animals closer to the detonation point (probably within the range of eardrum rupture) could experience permanent hearing loss.

In Appendix E, a conservative range for marine mammal acoustic discomfort at the Mayport and Norfolk areas has been defined as 11.11 km (6 nmi). Assuming that sea turtle sensitivity is equal to or less than that of marine mammals, the same range can be used to estimate the potential for sea turtle acoustic discomfort. To estimate how many sea turtles could experience acoustic discomfort, the same methods and assumptions were used as described above under Marine Mammals. Species historically present at or near each area but not seen during 1995 aerial surveys (i.e., green, hawksbill, and Kemp's ridley turtles) were taken into account in the calculations. Each species was

Table G-6. Estimates of potential mortality, injury, and acoustic discomfort for listed sea turtles potentially occurring at the Mayport area, with and without mitigation. Shock testing would only be conducted "with mitigation," including no testing in April at Mayport. Numbers are given to two decimal places to indicate the relative risk to various species. Species historically present in the region but not seen at Mayport during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
Loggerhead sea turtle (T)	1.11	5.74	51.92	0.08	1.02	5.27	51.92	5.08	26.36	259.62
Leatherback sea turtle (E)	0.08	0.43	3.88	0.10	0.07	0.39	3.88	0.37	1.94	19.37
Unidentified sea turtle (E or T)	0.04	0.23	2.11	0.09	0.04	0.21	2.11	0.21	1.06	10.57
* Green sea turtle (T)	0	0	0.20	NA	0	0	0.20	0	0	1
* Hawksbill sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Kemp's ridley sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1

(E) = endangered species. (T) = threatened species. NA = not applicable. * = species historically present in the region but not seen at the Mayport area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities for May through September at Mayport, scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).

b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).

c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

Table G-7. Estimates of potential mortality, injury, and acoustic discomfort of listed sea turtles potentially occurring at the Norfolk area, with and without mitigation. Shock testing would only be conducted "with mitigation." Numbers are given to two decimal places to indicate the relative risk to various species. Species historically present in the region but not seen at Norfolk during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic discomfort.

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[c] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Acoustic Discomfort		Mortality	Injury	Acoustic Discomfort	Mortality	Injury	Acoustic Discomfort
Loggerhead sea turtle (T)	1.21	6.30	56.99	0.08	1.11	5.78	56.99	5.57	28.92	284.93
Leatherback sea turtle (E)	0.02	0.12	1.08	0.10	0.02	0.11	1.08	0.11	0.54	5.40
Unidentified sea turtle (E/T)	0.08	0.39	3.53	0.09	0.07	0.36	3.53	0.34	1.78	17.66
* Green sea turtle (T)	0	0	0.20	NA	0	0	0.20	0	0	1
* Hawksbill sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1
* Kemp's ridley sea turtle (E)	0	0	0.20	NA	0	0	0.20	0	0	1

(E) = endangered species. (T) = threatened species. NA = not applicable. * = species historically present in the region but not seen at the Norfolk area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities for April through September at Norfolk, scaled to the area within the range for mortality (7.30 km^2 or 2.13 nmi^2), injury (37.87 km^2 or 11.03 nmi^2), or acoustic discomfort (342.70 km^2 or 99.78 nmi^2).

b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).

c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

assigned a value of 0.2 individuals per detonation, for a total of 1 individual per 5 detonations.

Tables G-6 and G-7 summarize the results of the acoustic discomfort calculations for sea turtles at the Mayport and Norfolk areas, based on a single detonation. For five detonations "with mitigation," 293 animals could be affected at Mayport and 311 at Norfolk. As noted above, loggerheads make up over 90% of the population at both areas and are the species most likely to be affected. It is assumed that 1 individual each of the other three species (green, hawksbill, and Kemp's ridley) could be affected.

G.4.2.3 Behavioral Responses

Behavioral responses could occur at distances beyond the acoustic discomfort range discussed above. Sea turtles are thought to be capable of hearing low frequency sounds. Ridgway et al. (1969) suggested that optimal sea turtle hearing occurs in the range of 200 to 700 Hz, with useful sensitivity extending from approximately 60 to 1,000 Hz. Sensitivity falls off significantly below 200 Hz. Sea turtles may hear the brief (<50 msec) acoustic signal created by the proposed underwater detonations. This could result in behavioral effects, such as swimming toward the surface, abrupt movements, slight retractions of the head, and limb extension during swimming (Lenhardt et al., 1983; Lenhardt, 1994). However, animals outside the 11.11 km (6 nmi) range would not experience any hearing damage or even brief acoustic discomfort. In addition, each detonation would be a single momentary disturbance, and because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would hear more than one detonation. Therefore, no significant impact on movements, migration patterns, breathing, feeding, or other normal behaviors would be expected.

G.4.2.4 Impacts on Critical Habitat

Based on information received from the NMFS (Appendix C), no critical habitat for endangered or threatened sea turtles exists at or near the Mayport or Norfolk areas.

G.4.2.5 Other Indirect Impacts

Two indirect ways in which sea turtles could be affected are through (1) death and injury to prey species and (2) destruction of juvenile habitat (*Sargassum* rafts). Both impacts are unlikely to be significant at either the Mayport or Norfolk area.

Adult loggerheads feed primarily on benthic molluscs and crustaceans. It is not known whether loggerheads present at the Mayport and Norfolk areas feed there; however, no significant impacts to benthic prey organisms are expected (see Section 4.2.2.5 in the DEIS). Leatherback turtles are pelagic feeders, preferring coelenterates (jellyfish). Some jellyfish are likely to be killed during the blast, but it is unlikely that prey availability would be reduced. Due to turbulent mixing with adjacent waters, coelenterates from surrounding areas would quickly repopulate the small area affected. Given that test site selection and scheduling would be based on the low abundance of sea turtles, and given that the Mayport and Norfolk areas do not represent

recognized feeding grounds for loggerhead or leatherback sea turtles, the potential for significant indirect effects is very low.

As noted above, *Sargassum* rafts which may serve as habitat for loggerhead juveniles are easily detected by aerial observers. Rafts detected in the safety range would be investigated by the Marine Animal Recovery Team (MART) (see Section 5.0 in the DEIS). If any juvenile turtles are found associated with a *Sargassum* raft, the test would be postponed. Therefore, no impacts on juvenile turtle habitat are expected.

G.4.2.6 Summary and Conclusions

Potential direct impacts on sea turtles have been analyzed in detail in the preceding discussion. Possible direct impacts include mortality, injury, and acoustic discomfort. Possible indirect impacts to sea turtles due to explosion by-products and impacts to prey species have also been discussed but are considered not significant. Based on information received from the NMFS (Appendix C), no critical habitat for endangered or threatened sea turtles exists at or near the Mayport or Norfolk areas. Because potential impacts on sea turtles would be similar at the two areas, a single discussion is presented.

Estimated totals for five detonations at Mayport are 6 sea turtle mortalities and 30 injuries. At Norfolk, the estimated totals are 7 mortalities and 32 injuries. Most of the affected animals would be loggerheads, although it is possible that a leatherback turtle could be killed or injured at either site. As used in the impact analysis, the term "injury" refers to non-lethal injury from which an animal would be expected to recover on its own.

Although the accidental death of loggerhead sea turtles is possible at either area, the loss of a few individuals would not be likely to jeopardize the continued existence of the species. Murphy and Hopkins (1984) estimated that there were 14,150 nesting females utilizing southeast U.S. beaches in 1983, based on aerial and ground survey data. Also, the loss would be small compared with other human-induced mortalities such as those resulting from dredging, boat collisions, and commercial fisheries (NMFS and USFWS, 1991b). The estimated number of loggerheads killed annually by the offshore shrimping fleet in the southeastern U.S. and Gulf of Mexico ranges between 5,000 and 50,000 (Magnuson et al., 1990). Similarly, Henwood and Stuntz (1987) estimated that the offshore commercial shrimping fleet captures about 640 leatherbacks annually in the southeastern U.S., of which approximately 25% (160 animals annually) die from drowning.

In terms of acoustic discomfort, the total number of sea turtles potentially affected at Mayport is 293 individuals, including 260 loggerheads, 19 leatherbacks, and 11 unidentified turtles. At Norfolk, the total number of sea turtles potentially affected is 311 individuals, including 285 loggerheads, 5 leatherbacks, and 18 unidentified turtles. Green, hawksbill, and Kemp's ridley sea turtles are assumed to have 1 individual each affected at each area (even though these species are unlikely to be present). Acoustic discomfort would be a momentary disturbance that would not cause TTS and would not be expected to cause disruption of behavioral patterns such as migration, breathing, nursing, breeding, feeding, or sheltering. In addition, because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would experience this momentary discomfort more than once.

The numbers presented above are based on conservative assumptions which overestimate impacts at both Mayport and Norfolk. As described in Section 5.0 of the DEIS, the Navy proposes to select a specific test site with few, if any, sea turtles present. The proposed mitigation methods for SEAWOLF shock testing were used successfully during the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994). Detection of even one sea turtle within the safety range would result in postponement of detonation; therefore, the presence of sea turtles would most likely result in testing delays rather than impacts on these animals.

In conclusion, if either the Mayport or Norfolk area is selected, the proposed action is not likely to jeopardize the continued existence of any endangered or threatened marine turtle species or result in destruction or adverse modification of critical habitat. No critical habitat for endangered or threatened sea turtles exists within or near the Mayport or Norfolk area.

G.5 CUMULATIVE EFFECTS

Cumulative impacts are those resulting from the incremental effects of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of which agency or person undertakes them. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over time.

As described in Section 4.0 of the DEIS, the main impacts of the proposed shock testing would include release of chemical products into the ocean and atmosphere; deposition of metal fragments on the seafloor; mortality and injury of plankton and fish near the detonation point; possible mortality, injury, and acoustic discomfort of marine mammals and sea turtles; and possible interruption of commercial and recreational fishing activity in the test area. Because of the short-term nature of the proposed action and the minor and localized nature of the impacts, there would not be any incremental or synergistic impact on present or reasonably foreseeable future uses of either the Mayport or Norfolk area.

Shock testing would not be expected to result in accumulation of explosion products in the water column or atmosphere (see Section 4.2.1 of the DEIS). Both the Mayport and Norfolk areas are in deep, oceanic waters where the explosion products would be rapidly dispersed and mixed. No buildup of explosion products or chemical alteration of water quality resulting from underwater explosives testing is expected. Gases released into the atmosphere would also be rapidly dispersed and mixed. Metal fragments from the explosions would accumulate on the seafloor but would not be expected to produce adverse impacts; they would provide a substrate for growth of epibiota and attract fish.

The Navy is currently designing the New Attack Submarine (NSSN). The Navy's Live Fire Test and Evaluation Plan for the NSSN includes a ship shock test in 2005. The technical and operational requirements to shock test the NSSN would be similar to SEAWOLF and therefore, both the Mayport and Norfolk areas may be considered as potential shock test areas in the future. Other than the shock testing of the NSSN, there are no ongoing, planned, or reasonably foreseeable Navy actions which could have similar impacts on the marine environment, including listed species, at either the Mayport or Norfolk area. No other shock testing has been proposed for either area

during this time period. The petroleum industry has proposed offshore drilling at a location south of the Norfolk area (DOI, MMS, 1990), but the proposal has been postponed indefinitely (Oil and Gas Journal, 7 August 1995, p. 34).

G.6 DISCUSSION OF SPECIES RECOVERY PLANS

To promote the conservation of an endangered species, in compliance with the mandates of the Endangered Species Act, recovery plans are prepared by NMFS for marine mammals or jointly by NMFS and USFWS for sea turtles. As noted in Section G.2, a total of six species of endangered whales and five species of endangered or threatened sea turtles may be found at the Mayport or Norfolk areas, based on historical sighting records. Endangered whale species include blue whale, fin whale, humpback whale, northern right whale, sei whale, and sperm whale. Endangered sea turtle species include the hawksbill, Kemp's ridley, and leatherback sea turtles. Threatened sea turtle species are the green sea turtle and loggerhead sea turtle.

Recovery plans have been prepared for two of the endangered whale species (humpback whale and northern right whale). Updates of the two plans prepared in 1991 are currently underway but are not expected until late 1996 at the earliest. Recovery plans are either in progress (i.e., blue whale) or pending for the remaining endangered whale species (Payne, 1996). For sea turtles, recovery plans have been developed for all five of the listed sea turtle species historically noted off Norfolk and Mayport. Updates of each plan are either currently underway or planned (Coogan, 1996).

A brief synopsis of each plan is provided below and within **Table G-8** as a basis for the subsequent discussion of the compatibility of the proposed action with the goals and objectives of the recovery plans.

G.6.1 Humpback Whale Recovery Plan

The Humpback Whale Recovery Plan (NMFS, 1991a) identifies as its long-term goal the intent to increase humpback whale populations to at least 60% of the number existing before commercial exploitation or of current environmental carrying capacity. Given that either level cannot be determined at present, NMFS has established, as an interim goal of the Plan, to realize a doubling in population size for the humpback whale populations addressed in the Plan by 2011. NMFS (1991a) notes four major objectives of the Plan, as follows: (1) to maintain and enhance habitat; (2) to identify and reduce human-related mortality; (3) to measure and monitor key population parameters to determine if recommended actions are successful; and (4) to improve administration and coordination of the overall recovery effort for this species.

Ultimately, the goal of the Plan is to be "biologically successful" (i.e., occupation of all of their former range in sufficient abundance) to buffer humpback whale populations against normal environmental fluctuations or anthropogenic environmental catastrophes. According to NMFS (1991a), the best estimator of success is if the Plan is "numerically successful" (i.e., reaching or approaching carrying capacity), to be followed by possible reclassification or elimination of the humpback whale population from endangered or threatened status.

Table G-8. Summary and comparison of recovery plan components.

Species	Long-Term and/or Interim Goal(s)	Objectives	No. of Tasks
Humpback whale	To increase humpback whale populations to at least 60% of the number existing before commercial exploitation or of current environmental carrying capacity; both levels cannot be determined at present. Interim goal is to realize a doubling in population size for the humpback whale populations addressed in the Plan by 2011.	(1) maintain and enhance habitat; (2) identify and reduce human-related mortality; (3) measure and monitor key population parameters; and (4) improve administration/coordination of the overall recovery effort	72
Northern right whale	To increase the Western North Atlantic population of the northern right whale to 60-80% of the number existing before commercial exploitation (i.e., between 6,000 and 8,000 individuals). Intermim goal: To change the status of the population from endangered to threatened, to be realized when: (1) the size of the Western North Atlantic population recovers to a level of 6,000 animals, (2) the population has been increasing steadily over a period of 20 years or more at an average annual net recruitment rate of at least 2%, and (3) an effective program is in place to control known northern right whale mortality factors and ensure that deterioration of essential habitat is not likely to occur; current recruitment rates and the diminished size of the population indicate that it may require 150-175 years to realize a change in status	(1) reduce or eliminate injury or mortality caused by ship collisions; (2) maximize efforts to free entangled or stranded whales, acquire data from dead specimens; (3) identify and protect habitats essential to the survival and recovery of the species; (4) monitor population size and trends in abundance of the species; (5) determine and minimize any detrimental effects of directed air and water craft interactions; and (6) coordinate Federal, state, international, and private efforts to implement the recovery effort	68
Atlantic green sea turtle	To delist the species in the U.S. once recovery criteria are met. Recovery criteria applicable to the U.S. population; over a period of 25 years: (1) Florida nesting must increase to an average of 5,000 nests per year for at least 6 years, (2) at least 25% (i.e., 105 km) of all available nesting beaches (420 km) must be in public ownership and encompass >50% of nesting activity, (3) a reduction in stage class mortality must be reflected in higher counts of individuals on foraging grounds, and (4) all priority one tasks must be successfully implemented. Anticipated recovery date is 2015.	(1) provide long-term protection to important nesting beaches; (2) ensure at least 60% hatch success on major nesting beaches; (3) implement effective lighting ordinances or lighting plans on nesting beaches; (4) determine distribution and seasonal movements for all life stages in the marine environment; (5) minimize mortality from commercial fisheries; and (6) reduce the threat to population and foraging habitat from marine pollution.	62
Hawksbill sea turtle	To delist the species once recovery criteria are met. Recovery criteria applicable to U.S. population. Species can be considered for delisting if, over a period of 25 years: (1) the adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on at least five index beaches, (2) habitat for at least 50% of the nesting activity in the U.S. Virgin Islands and Puerto Rico is protected in perpetuity, (3) numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, U.S. Virgin Islands, and Florida, and (4) all priority one tasks have been successfully implemented. Anticipated year of recovery is 2020.	(1) provide long-term protection to important nesting beaches; (2) ensure at least 75% hatching success rate on major nesting beaches; (3) determine the distribution and seasonal movements of turtles in all life stages in the marine environment; (4) minimize the threat from illegal exploitation; and (5) ensure long-term protection of important foraging habitats.	22

Table G-8. (continued)

Species	Long-Term and/or Interim Goal(s)	Objectives	No. of Tasks
Kemp's ridley sea turtle	To remove the species from the endangered listing and downlist to threatened status. Requires a coordinated approach between U.S. and Mexico. Comprehensive criteria for delisting not specified. U.S. criteria for delisting include: (1) to continue complete and active protection of the known nesting habitat, and the waters adjacent to the nesting beach and continue the bi-national protection project, (2) to essentially eliminate mortality from incidental catch in commercial shrimping in the U.S. and Mexico through use of TEDs, and to achieve full compliance with the regulations requiring TED use, (3) to attain a population of at least 10,000 females nesting in a season, and (4) to successfully implement all priority one recovery tasks. Dowlisting could be initiated in 2020.	(1) assist Mexico to ensure long-term protection of major nesting beaches and (their) environs, including the protection of the adult breeding stock and enhanced production/survival of hatchling turtles; (2) continue TED regulation enforcement in U.S. waters, expanding the areas and seasonality of required TED use to reflect the distribution of the species and encouraging and assisting Mexico to incorporate TEDs in their Gulf of Mexico shrimping fleet; and (3) fill in gaps in knowledge that will result in better management (i.e., to minimize threats and maximize recruitment: determine distribution and habitat use for all life stages, determine critical mating/reproductive behaviors and physiology, and determine survivorship and recruitment).	25
Leatherback sea turtle	To delist the species once recovery criteria are met. U.S. population of leatherback turtles to be considered for delisting if, over a period of 25 years: (1) adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on Culebra Island, Puerto Rico, St. Croix, Virgin Islands, and along the east coast of Florida, (2) nesting habitat for at least 75% of the nesting activity in the U.S. Virgin Islands, Puerto Rico, and Florida is in public ownership, and (3) all priority one tasks have been successfully implemented. Anticipated year of recovery is 2015.	(1) provide long-term habitat protection for important nesting beaches; (2) ensure at least 60% hatching success on major nesting beaches; (3) determine distribution and seasonal movements for all life stages in the marine environment; (4) reduce threat from marine pollution; and (5) reduce incidental capture by commercial fisheries.	50
Loggerhead sea turtle	To delist the species in the U.S. once recovery criteria are met. Recovery criteria applicable to the southeastern U.S. population; over a period of 25 years: (1) adult female Florida population must increase, with a return to prelisting nesting levels in NC (800 nests/season), SC (10,000 nests/season), and GA (2,000 nests/season), (2) at least 25% (i.e., 560 km) of all available nesting beaches (2,240 km) must be in public ownership, distributed over entire nesting range and encompassing >50% of nesting activity, and (3) all priority one tasks successfully implemented. Anticipated recovery date is 2015.	(1) provide long-term protection to important nesting beaches; (2) ensure at least 60% hatch success on major nesting beaches; (3) implement effective lighting ordinances or lighting plans on nesting beaches within each State; (4) determine distribution and seasonal movements for all life stages in the marine environment; (5) minimize mortality from commercial fisheries; and (6) reduce the threat from marine pollution.	69

In an effort to meet these objectives, the Plan identifies and discusses 72 separate or interrelated recommended recovery actions, prioritizes each action (task), outlines task duration and responsible agency or entity (cooperators), and estimates costs associated with each task.

The Plan identifies eight human-induced factors which may affect either habitat or prey (or both) of humpback whales, effectively impeding recovery. These factors include (1) subsistence hunting, (2) incidental entrapment or entanglement in fishing gear, (3) collision with ships, (4) disturbance or displacement caused by noise and other factors associated with shipping, recreational boating, high-speed thrill craft, whale watching, or air traffic, (5) introduction and/or persistence of pollutants and pathogens from waste disposal, (6) disturbance and/or pollution from oil, gas, or other mineral exploration and production activities, (7) habitat degradation or loss associated with coastal development, and (8) competition with fisheries for prey species. These factors, either individually or in concert with one another, may affect individual reproductive success, alter survival, and/or limit the availability of necessary habitat.

G.6.2 Northern Right Whale Recovery Plan

The Northern Right Whale Recovery Plan (NMFS, 1991b) cites as is long-term goal the intent to increase the Western North Atlantic population of the northern right whale to 60-80% of the number existing before commercial exploitation (i.e., between 6,000 and 8,000 individuals). The interim goal of the Plan is to change the status of the population from endangered to threatened, to be realized when: (1) the size of the Western North Atlantic population recovers to a level of 6,000 animals, (2) the population has been increasing steadily over a period of 20 years or more at an average annual net recruitment rate of at least 2%, and (3) an effective program is in place to control known northern right whale mortality factors and ensure that deterioration of essential habitat is not likely to occur. Current recruitment rates and the diminished size of the population indicate that it may require 150-175 years to realize such a change in status.

Six major objectives of the Plan pertinent to the Western North Atlantic northern right whale population include: (1) to reduce or eliminate injury or mortality caused by ship collisions; (2) to maximize efforts to free entangled or stranded northern right whales and acquire scientific information from dead specimens; (3) to identify and protect habitats essential to the survival and recovery of the northern right whale; (4) to monitor the population size and trends in abundance of the northern right whale; (5) to determine and minimize any detrimental effects of directed air and water craft interactions; and (6) to coordinate Federal, state, international, and private efforts to implement this recovery effort.

For the Western North Atlantic population, and in an effort to meet these objectives, the Plan identifies and discusses 68 separate or interrelated recommended recovery actions (tasks), prioritizes each task, outlines task duration and responsible agency or entity, and estimates costs associated with each task.

The Plan identifies three human-induced factors which may affect either habitat or prey (or both) of northern right whales, thereby impeding recovery. These factors include (1) vessel interactions (collisions with ships, disturbance from vessels), (2) entrapment or entanglement in fishing gear (gillnets, lines from lobster pots, seines,

and fish weirs), and (3) habitat degradation (oil, gas, and mineral exploration and production activities, wastewater discharges, dredging activities). Hunting was identified in the Plan as a component of human impact on northern right whales, however, this factor is no longer considered significant. These three factors, either individually or in concert with one another, may affect individual reproductive success, alter survival, and/or limit the availability of necessary habitat.

G.6.3 Atlantic Green Turtle Recovery Plan

The Atlantic Green Turtle Recovery Plan (NMFS and USFWS, 1991a) identifies as its long-term goal the intent to delist the species in the U.S. once recovery criteria are met. Recovery criteria apply to the U.S. population of green sea turtles; recovery will be considered successful and the species can be considered for delisting if, over a period of 25 years: (1) the level of nesting in Florida has increased to an average of 5,000 nests per year for at least 6 years, (2) at least 25% (i.e., 105 km) of all available nesting beaches (420 km) is in public ownership and encompasses greater than 50% of the nesting activity, (3) a reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds, and (4) all priority one tasks have been successfully implemented. The anticipated recovery date is 2015, if funds are available to accomplish recovery tasks and new data does not indicate other limiting factors.

Six major objectives or actions of the Plan include: (1) to provide long-term protection to important nesting beaches; (2) to ensure at least 60% hatch success on major nesting beaches; (3) to implement effective lighting ordinances or lighting plans on nesting beaches; (4) to determine distribution and seasonal movements for all life stages in the marine environment; (5) to minimize mortality from commercial fisheries; and (6) to reduce the threat to population and foraging habitat from marine pollution.

In an effort to meet these objectives, the Plan identifies and discusses 62 separate or interrelated recommended recovery actions (tasks), prioritizes each task, outlines task duration and responsible agency or entity, and estimates costs associated with each task.

The Plan identifies a series of human-induced factors (i.e., threats) which may affect green sea turtle beach habitat or nesting activities, thereby impeding recovery. These factors include (1) beach erosion, (2) beach armoring, (3) beach nourishment, (4) artificial lighting, (5) beach cleaning, (6) increased human presence, (7) recreational beach equipment, (8) beach vehicular driving, (9) exotic dune and beach vegetation, (10) nest depredation, (11) nest loss to abiotic factors, and (12) poaching. Marine environmental threats which may affect green sea turtle recovery include (1) oil and gas exploration, development, and transportation, (2) dredging, (3) marina and dock development, (4) pollution, (5) seagrass bed degradation, (6) trawl fisheries, (7) purse seine fisheries, (8) hook and line fisheries, (9) gill net fisheries, (10) pound net fisheries, (11) longlining fisheries, (12) trap fisheries, (13) boat collisions, (14) power plant entrapment, (15) underwater explosions, (16) offshore artificial lighting, (17) entanglement, (18) ingestion of marine debris, (19) poaching, (20) predation, and (21) diseases and parasites. These factors, either individually or in concert with one another, may affect individual reproductive success, alter survival, and/or limit the availability of necessary habitat.

G.6.4 Hawksbill Turtle Recovery Plan

The Hawksbill Turtle Recovery Plan (NMFS and USFWS, 1993) has identified as its long-term Plan goal the intent to delist the species once recovery criteria are met. Recovery criteria are applicable to the U.S. population of hawksbill sea turtles. This species can be considered for delisting if, over a period of 25 years: (1) the adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on at least five index beaches, including Mona Island (Puerto Rico) and Buck Island Reef National Monument (BIRNM), St. Croix, U.S. Virgin Islands, (2) habitat for at least 50% of the nesting activity that occurs in the U.S. Virgin Islands and Puerto Rico is protected in perpetuity, (3) numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, U.S. Virgin Islands, and Florida, and (4) all priority one tasks have been successfully implemented. According to the Plan, the anticipated year of recovery is 2020, if funds are available to accomplish recovery tasks and if new data does not indicate other limiting factors.

Five major objectives (actions) of the Plan include: (1) to provide long-term protection to important nesting beaches; (2) to ensure at least 75% hatching success rate on major nesting beaches; (3) to determine the distribution and seasonal movements of sea turtles in all life stages in the marine environment; (4) to minimize the threat from illegal exploitation; and (5) to ensure long-term protection of important foraging habitats.

The Plan identifies and discusses 22 separate or interrelated recommended recovery actions (tasks), prioritizes each task, outlines task duration and responsible agency or entity, and estimates costs associated with each task.

The Plan identifies a series of human-induced factors (i.e., threats) which may affect hawksbill sea turtle beach habitat or nesting activities, thereby impeding recovery. The factors cited for hawksbills are very similar to those listed for green and loggerhead sea turtles, including (1) illegal exploitation, (2) beach erosion, (3) erosion control methods, (4) sand mining, (5) landscaping, (6) artificial lighting, (7) beach cleaning, (8) increased human presence, (9) beach vehicular driving, and (10) nest depredation. Marine environmental threats which may affect hawksbill sea turtle recovery include (1) entanglement at sea, (2) ingestion of marine debris, (3) commercial and/or recreational fisheries (shrimping, commercial and recreational trawl fishing, gill netting, seines, drift netting, and speargunning), (4) watercraft collisions, (5) sedimentation and siltation, (6) agricultural and industrial pollution, (7) sewage, (8) illegal exploitation, (9) oil and gas exploration, development, transportation, and storage, (10) anchoring and vessel groundings, and (11) international trade. These factors, either individually or in concert with one another, may affect individual reproductive success, alter survival, and/or limit the availability of necessary habitat. The use of underwater explosives use not noted among 21 threats to nesting (beach) and marine environments.

G.6.5 Kemp's Ridley Sea Turtle Recovery Plan

The Kemp's Ridley Sea Turtle Recovery Plan (NMFS and USFWS, 1992a) identifies as its long-term goal the intent to remove the species from the endangered listing and downlist to threatened status. Given the need for a coordinated approach to recovery between the U.S. and Mexico, comprehensive criteria for delisting were not

specified in the Plan and were deferred to a later recovery plan. However, the U.S. criteria for delisting include: (1) to continue complete and active protection of the known nesting habitat, and the waters adjacent to the nesting beach (concentrating on the Rancho Nuevo [southern Tamaulipas, Mexico] area) and continue the bi-national protection project, (2) to essentially eliminate mortality from incidental catch in commercial shrimping in the U.S. and Mexico through use of turtle excluder devices (TEDs), and to achieve full compliance with the regulations requiring TED use, (3) to attain a population of at least 10,000 females nesting in a season, and (4) to successfully implement all priority one recovery tasks. According to the Plan, downlisting could be initiated in 2020, if all recovery tasks are completed, the population increases in accordance with projections, and new limiting factors are not encountered.

Three major objectives (actions) of the Plan include: (1) to assist Mexico to ensure long-term protection of major nesting beaches and (their) environs, including the protection of the adult breeding stock and enhanced production/survival of hatchling sea turtles; (2) to continue TED regulation enforcement in U.S. waters, expanding the areas and seasonality of required TED use to reflect the distribution of the species and encouraging and assisting Mexico to incorporate TEDs in their Gulf of Mexico shrimping fleet; and (3) to fill in gaps in knowledge that will result in better management (i.e., to minimize threats and maximize recruitment: determine distribution and habitat use for all life stages, determine critical mating/reproductive behaviors and physiology, and determine survivorship and recruitment).

The Plan identifies and discusses 25 separate or interrelated recommended recovery actions (tasks), prioritizes each task, outlines task duration and responsible agency or entity, and estimates costs associated with each task.

The Plan identifies a series of human-induced factors (i.e., threats) which may affect Kemp's ridley sea turtle beach habitat or nesting activities, thereby impeding recovery. The factors cited for Kemp's ridley sea turtles are very similar to those listed for green and loggerhead sea turtles, including (1) human population growth and increasing development pressure in proximity to nesting beaches, (2) beach armoring, (3) beach nourishment, and (4) beach cleaning. Marine environmental threats which may affect Kemp's ridley sea turtle recovery include (1) commercial and/or recreational fisheries (shrimping, commercial and recreational trawl fishing, gill netting, hook and line fishing, purse seines, beach seines, pound netting, crab trapping, longlining), (2) marine pollution and debris, (3) dredging, (4) explosive removal of oil and gas platforms, (5) boat collisions, (6) power plant entrapment, and (7) other human activities within foraging grounds. These factors, either individually or in concert with one another, may affect individual reproductive success, alter survival, and/or limit the availability of necessary habitat.

G.6.6 Leatherback Turtle Recovery Plan

The Leatherback Turtle Recovery Plan (NMFS and USFWS, 1992b) identifies as its long-term goal the intent to delist the species once recovery criteria are met. As recovery criteria, the U.S. population of leatherback sea turtles can be considered for delisting if, over a period of 25 years: (1) the adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on Culebra Island, Puerto Rico, St. Croix, Virgin Islands, and along the east coast of Florida,

(2) nesting habitat for at least 75% of the nesting activity in the U.S. Virgin Islands, Puerto Rico, and Florida is in public ownership, and (3) all priority one tasks have been successfully implemented. According to the Plan, the anticipated year of recovery is 2015, if funds are available to accomplish recovery tasks and if new data does not indicate other limiting factors.

Five major objectives (actions) of the Plan include: (1) provide long-term habitat protection for important nesting beaches; (2) ensure at least 60% hatching success on major nesting beaches; (3) determine distribution and seasonal movements for all life stages in the marine environment; (4) reduce threat from marine pollution; and (5) reduce incidental capture by commercial fisheries.

The Plan identifies and discusses 50 separate or interrelated recommended recovery actions (tasks), prioritizes each task, outlines task duration and responsible agency or entity, and estimates costs associated with each task. The use of underwater explosives use was not noted among the identified threats to nesting (beach) and marine environments.

The Plan identifies a series of human-induced factors (i.e., threats) which may affect leatherback sea turtle beach habitat or nesting activities, thereby impeding recovery. These factors are identical to those noted for green (and loggerhead) sea turtles. Marine environmental threats are also identical to those noted for green sea turtles. These factors, either individually or in concert with one another, may affect individual reproductive success, alter survival, and/or limit the availability of necessary habitat.

G.6.7 Loggerhead Turtle Recovery Plan

The Loggerhead Turtle Recovery Plan (NMFS and USFWS, 1991b) identifies as its long-term goal the intent to delist the species in the U.S. once recovery criteria are met. As recovery criteria, the southeastern U.S. population of loggerhead sea turtles can be considered for delisting if, over a period of 25 years: (1) the adult female population in Florida increases and has returned to pre-listing nesting levels in North Carolina (800 nests/season), South Carolina (10,000 nests/season), and Georgia (2,000 nests/season), (2) at least 25% (i.e., 560 km) of all available nesting beaches (2,240 km) is in public ownership, is distributed over the entire nesting range and encompasses greater than 50% of the nesting activity, and (3) all priority one tasks have been successfully implemented. According to the Plan, the anticipated recovery date is 2015, if funds are available to accomplish recovery tasks and new data does not indicate other limiting factors.

Six major objectives (actions) of the Plan include: (1) to provide long-term protection to important nesting beaches; (2) to ensure at least 60% hatch success on major nesting beaches; (3) to implement effective lighting ordinances or lighting plans on nesting beaches within each State; (4) to determine distribution and seasonal movements for all life stages in the marine environment; (5) to minimize mortality from commercial fisheries; and (6) to reduce the threat from marine pollution.

The Plan identifies and discusses 69 separate or interrelated recommended recovery actions (tasks), prioritizes each task, outlines task duration and responsible agency or entity, and estimates costs associated with each task.

The Plan identifies a series of human-induced factors (i.e., threats) which may affect loggerhead sea turtle beach habitat or nesting activities, thereby impeding recovery. The 12 factors cited for loggerhead sea turtles are identical to those listed for green sea turtles. Marine environmental threats which may affect loggerhead sea turtle recovery are also identical, with one exception, to those listed 21 factors listed for green sea turtles. The single exception within the loggerhead listing is the absence of seabed grass degradation. These factors, either individually or in concert with one another, may affect individual reproductive success, alter survival, and/or limit the availability of necessary habitat.

G.6.8 Compatibility of the Proposed Action with Recovery Plans

As explained in Section 1.0 of the DEIS, the Navy has a purpose and need which can only be met by shock testing the SEAWOLF submarine at an offshore location. Section 2.0 of the DEIS evaluates alternative areas for the proposed action and indicates that only the Mayport and Norfolk areas meet all of the Navy's operational requirements. To the extent possible given the need for shock testing and the Navy's operational requirements, the proposed action is compatible with the goals and objectives of existing recovery plans for endangered and threatened marine mammals and turtles.

- In Section 2.0 of the DEIS, the Navy has indicated that Mayport is the preferred alternative area based on the lower density of marine mammals. This is compatible with the general goal of minimizing human-induced mortality or injury to marine mammals and sea turtles, including listed and proposed species.

- The extensive mitigation program described in Section 5.0 of the DEIS includes site selection, pre-detonation monitoring, post-detonation monitoring designed to minimize the possibility of death or injury to marine mammals and sea turtles. This is compatible with the general goal of minimizing human-induced mortality or injury to marine mammals and sea turtles, including listed and proposed species.

- Elimination of April testing at Mayport to avoid high sea turtle densities is compatible with the general goal of minimizing human-induced mortality or injury to sea turtles, including listed species.

- Aerial surveys that would be conducted during the proposed action would provide increased information about the abundance and distribution of marine mammal and sea turtle species at sea. This would be in addition to the information already obtained during the 1995 aerial surveys conducted to support preparation of this DEIS.

Most of the human-induced factors which have been identified as potential threats to recovery of the listed species are not relevant to the proposed action

(**Table G-9**). Two potential impacts of the proposed action which do occur on the list are impacts of underwater explosions (for hawksbill, leatherback, and loggerhead sea turtles) and vessel collisions (for all species). The mitigation plan described in Section 5.0 is designed to minimize the risk to sea turtles from underwater explosions; it is consistent with, but more extensive than, the mitigation efforts required by NMFS for explosive removal of oil and gas platforms (Department of the Interior, Minerals Management Service, 1994). The likelihood of a vessel colliding with a mammal or turtle during the proposed action is extremely low due to the combination of surface and aerial observers and passive acoustic monitoring that would be used to detect these animals.

G.7 CONCLUSIONS

The purpose of the Biological Assessment is "to evaluate the potential effects of the action on listed and proposed species and designated and proposed critical habitat and determine whether any such species or habitat are likely to be adversely affected by the action" (50 CFR 402.12). Based on the Biological Assessment, the NMFS will prepare a Biological Opinion. The proposed action cannot occur unless the Biological Opinion concludes that shock testing is not likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat.

Potential impacts on marine mammals have been analyzed in detail in Section 4.0 of the DEIS, and impacts on listed species have been analyzed in Section G.4.1. Possible direct impacts evaluated include mortality, injury, acoustic discomfort, and behavioral responses. Possible indirect impacts to marine mammals due to explosion by-products and impacts to prey species have also been discussed. Based on this analysis and the conclusions in Section G.4.1.7, if either the Mayport or Norfolk area is selected, the proposed action is not likely to jeopardize the continued existence of any endangered, threatened, or candidate marine mammal species or result in destruction or adverse modification of their critical habitat.

Potential impacts on sea turtles have been analyzed in detail in Section 4.0 of the DEIS, and impacts on listed species have been analyzed in Section G.4.2. Possible direct impacts evaluated include mortality, injury, acoustic discomfort, and behavioral responses. Possible indirect impacts to sea turtles due to explosion by-products and impacts to prey species have also been discussed. Based on this analysis and the conclusions in Section G.4.2.6, if either the Mayport or Norfolk area is selected, the proposed action is not likely to jeopardize the continued existence of any endangered or threatened marine turtle species or result in destruction or adverse modification of their critical habitat.

Table G-9. Evaluation of human-induced factors identified in recovery plans as affecting the recovery of listed species, in relation to the proposed action.

Recovery Plan and Effects Factors	Potential Impact of Proposed Action
Humpback Whale Recovery Plan (NMFS, 1991a):	
(1) subsistence hunting	No
(2) incidental entrapment or entanglement in fishing gear	No
(3) collision with ships	Not likely
(4) disturbance/displacement (noise, factors assoc. w/ shipping, recreat. boating, thrill craft, whale watching, air traffic)	No
(5) introduction and/or persistence of pollutants and pathogens from waste disposal	No
(6) disturbance and/or pollution from oil, gas, or other mineral exploration and production activities	No
(7) habitat degradation or loss associated with coastal development	No
(8) competition with fisheries for prey species	No
Northern Right Whale Recovery Plan (NMFS, 1991b):	
(1) vessel interactions (collisions with ships, disturbance from vessels)	Not likely
(2) entrapment or entanglement in fishing gear (gillnets, lines from lobster pots, seines, and fish weirs)	No
(3) habitat degradation (oil, gas, and mineral exploration/production, wastewater discharges, dredging activities)	No
Atlantic Green Turtle Recovery Plan (NMFS and USFWS, 1991a):	
(1) oil and gas exploration, development, and transportation	No
(2) dredging	No
(3) marina and dock development	No
(4) pollution	No
(5) seagrass bed degradation	No
(6)-(12) trawl, purse seine, hook and line, gill net, pound net, longlining, trap fisheries	No
(13) boat collisions	Not likely
(14) power plant entrapment	No
(15) underwater explosions	Possible
(16) offshore artificial lighting	No
(17) entanglement	No
(18) ingestion of marine debris	No
(19) poaching	No
(20) predation	No
(21) diseases and parasites	No
Hawksbill Turtle Recovery Plan (NMFS and USFWS, 1993):	
(1) entanglement at sea	No
(2) ingestion of marine debris	No
(3) commercial and/or recreational fisheries (shrimping, commercial and recreational trawl fishing, gill netting, seines, drift netting, speargunning)	No
(4) watercraft collisions	Not likely
(5) sedimentation and siltation	No
(6) agricultural and industrial pollution	No
(7) sewage	No
(8) illegal exploitation	No
(9) oil and gas exploration, development, transportation, and storage	No
(10) anchoring and vessel groundings	No
(11) international trade	No

Table G-9. (Continued).

Recovery Plan and Effects Factors	Potential Impact of Proposed Action
Kemp's Ridley Sea Turtle Recovery Plan (NMFS and USFWS, 1992a):	
(1) commercial and/or recreational fisheries (shrimping, commercial and recreational trawl fishing, gill netting, hook and line fishing, purse seines, beach seines, pound netting, crab trapping, longlining)	No
(2) marine pollution and debris	No
(3) dredging	No
(4) explosive removal of oil and gas platforms	Possible
(5) boat collisions	Not likely
(6) power plant entrapment	No
(7) other human activities within foraging grounds	No
Leatherback Turtle Recovery Plan (NMFS and USFWS, 1992b):	
(1) oil and gas exploration, development, and transportation	No
(2) dredging	No
(3) marina and dock development	No
(4) pollution	No
(5) seagrass bed degradation	No
(6)-(12) trawl, purse seine, hook and line, gill net, pound net, longlining, trap fisheries	No
(13) boat collisions	Not likely
(14) power plant entrapment	No
(15) underwater explosions	Possible
(16) offshore artificial lighting	No
(17) entanglement	No
(18) ingestion of marine debris	No
(19) poaching	No
(20) predation	No
(21) diseases and parasites	No
Loggerhead Turtle Recovery Plan (NMFS and USFWS, 1991b):	
(1) oil and gas exploration, development, and transportation	No
(2) dredging	No
(3) marina and dock development	No
(4) pollution	No
(5)-(11) trawl, purse seine, hook and line, gill net, pound net, longlining, trap fisheries	No
(12) boat collisions	Not likely
(13) power plant entrapment	No
(14) underwater explosions	Possible
(15) offshore artificial lighting	No
(16) entanglement	No
(17) ingestion of marine debris	No
(18) poaching	No
(19) predation	No
(20) diseases and parasites	No

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